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An Improved and GNSS Patch Antenna Techniques for Analysis and Estimation of Phase Centre

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Abstract: **This paper proposes the estimation of mean electrical phase center (MEPC) in different GNSS patch antennas. In the past, edge diffraction theory is quite complex and difficult to find the exact location of antenna phase center. In this work, an improved and determine the mean electrical phase center of horn and patch antenna in Cartesian coordinates. The Patch antenna can provide higher accuracy in GNSS positioning compare to horn antenna. The experimental results show that the patch and horn antenna phase center variation with change in observation angle and frequency are presented.**

Keywords: **Anechoic chamber, antenna, global navigation satellite system (GNSS), patch, phase center.**

I. INTRODUCTION

GNSS antennas are attractive due to their light weight, conformability and low cost [1]. These antennas can be integrated with printed strip-line feed networks and active devices. This is relatively new area of antenna engineering. The radiation properties of micro strip structures have been known since the mid 1950‟s.[2] The application of this type of antennas started in early 1970‟s when conformal antennas were required for missiles. Rectangular and circular micro strip resonant patches have been used extensively in a variety of array configurations. A major contributing factor for recent advances of GNSS antennas is the current revolution in electronic circuit miniaturization brought about by developments in large scale integration.

Various modeling methods have been suggested in open literature for estimation of error caused due to bias timing, multipath and propagation delays for precise positioning and its subsequent minimization [3], [4]. In GNSS and its augmentation systems, antenna PC displacement is one of the most significant sources of error, because the pseudo range determined by the time correlative receiver is always proportional to the PC separation between transmitting and receiving antennas [5]. Thus, the precise location of the PC when accounted in the measurements will lead to highly accurate positioning and navigation.

This paper discusses mean electrical phase center (MEPC) with various antennas. The variation of MEPC with frequency and angle for a wideband axial horn and planar GNSS patch antenna has been estimated. In this paper is organized as follows. GNSS patch antenna in section II. Explain the horn antenna in section III. The simulation results are presented in Section IV. Concluding remarks are made in Section V.

II. GNSS PATCH ANTENNA

GNSS patch antennas are increasing in popularity for use in wireless applications due to their low-profile structure. Therefore they are extremely compatible for embedded antennas in handheld wireless devices such as cellular phones, pagers etc... .the GNSS patch antenna handles the Lower gain and lower power.

This phase centre location on the evolutes can be obtained by finding the point of interaction of successive normal lines of two successive angles $\gamma 1$ and $\gamma 2$. The intersection points of PC location is derived as

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$$X = \frac{d_2 \tan\gamma_2 - d_1 \tan\gamma_1}{\tan\gamma_1 - \tan\gamma_2}$$

$$Y = \frac{(d_2 - d_1)\tan\gamma_1 \tan\gamma_2}{\tan\gamma_1 - \tan\gamma_2}.$$

Where d1,d2 are the distance between phase centre and intersects the x-axis at points D1 and D2 as shown in figure1. Geometry for analysis of phase centre as shown in figure1.

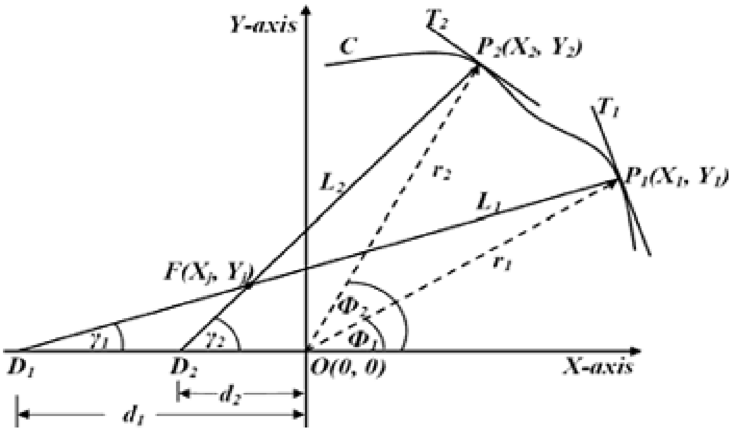

Figure.1. Geometry for analysis of phase centre

The PC points Pi (Xi, Yi) can be derived as

$$(X_j, Y_j) = \left[\frac{d_{i+1}\tan\phi_{i+1} - d_i \tan\phi_i}{\tan\phi_i - \tan\phi_{i+1}}, \frac{(d_{i+1} - d_i)\tan\phi_i \tan\phi_{i+1}}{\tan\phi_i - \tan\phi_{i+1}}\right]$$

It represent the PC location of i^{th} angular segment. The measured phase centre for the antenna at 1.2 GHz. This measurement was repeated for other frequencies of the patch over 1.1–1.7 GHz at 0.1 GHz interval for estimation of the mean electrical phase center. For the patch antenna the minimum 3-dB beam width of has been considered for estimation of its PC. PC variation of patch antenna beam with angle at 1.4 GHz as shown in figure 2

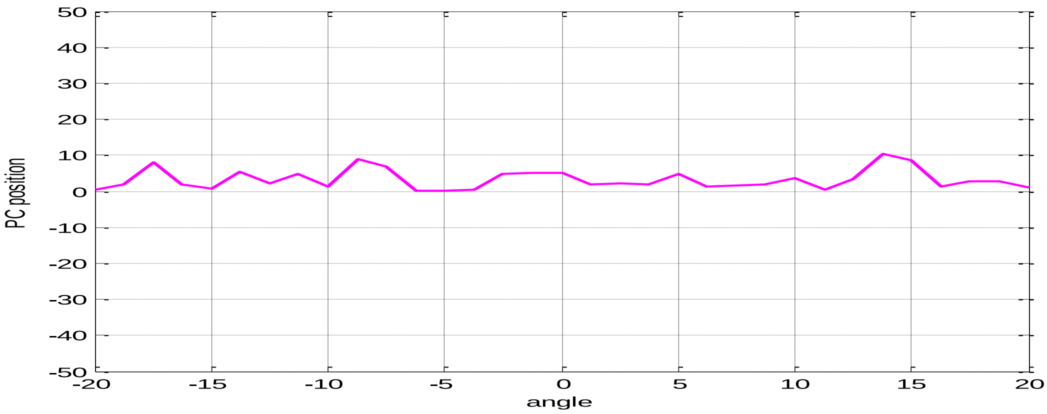

Fig. 2. PC variation of patch antenna beam with angle at 1.4 GHz

In figure 2, The PC for the L-band patch antenna was determined for various angles. The estimated PCs location for the patch antenna in Cartesian coordinates (x, y) as well as its radial distance in electrical units for different angles. The plots for radial displacement of PC from origin for different angles over the band of operation. Also, the estimated of MEPC position at various frequencies for patch antenna beam at a given frequency of 1.4 GHz. The Phase radiation pattern of GNSS patch antenna at 1.2 GHz is shown in figure 3. The radiation pattern measurement of the antennas produces lobes and nulls in its amplitude radiation pattern and discontinuities in the field phase patterns while passing over the spatial nulls. Hence, the calculations are limited to the angular area of the main lobe (3-dB beam width) where phase is rather steady to get consistent estimation of antenna PC.

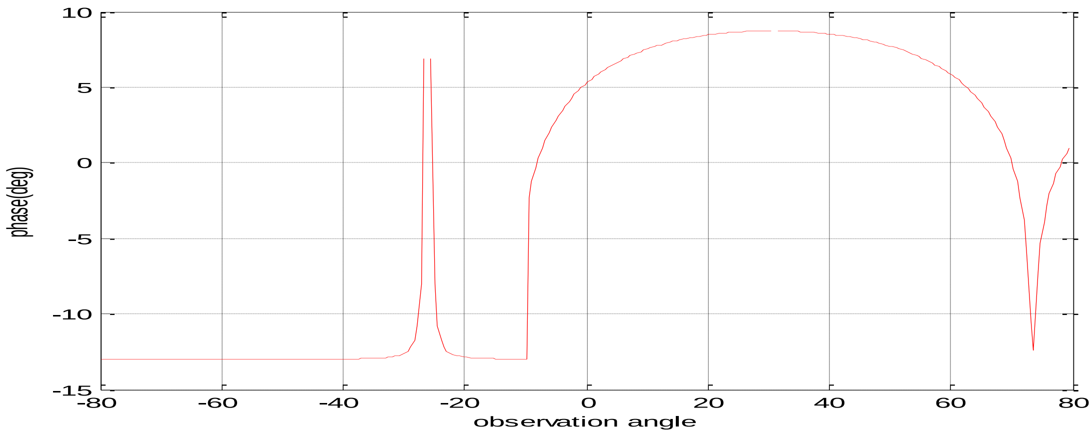

Figure 3. Phase radiation pattern of GNSS patch antenna at 1.2 GHz

The difference in phase between the center point and the edges is called the phase error. As the size of wavelengths is increased, the phase error increases, giving the patch a wider radiation pattern. Keeping the beam width narrow requires a longer patch (smaller flare angle) to keep the phase error constant. The increasing phase error limits the aperture size of practical horns to about 15 wavelengths; larger apertures would require impractically long patch. The estimated of phase pattern at various angles for patch antenna beam at a given frequency of 1.2GHz.

III. HORN ANTENNA

A horn antenna or microwave horn is an antenna that consists of a flaring metal waveguide shaped like a horn to direct radio waves in a beam. Horns are widely used as antennas at UHF and microwave frequencies, above 300 MHz. They are used as feeders (called feed horns) for larger antenna structures such as parabolic antennas, as standard calibration antennas to measure the gain of other antennas, and as directive antennas for such devices as radar guns, automatic door openers, and microwave radiometers. Their advantages are moderate directivity (gain), low standing wave ratio (SWR), broad bandwidth, and simple construction and adjustment.

The measured radiation phase data were used in post processing and calculation of phase centre at each frequency. The MEPC displacement of horn antenna with frequency 1.2 GHz as shown in figure 4

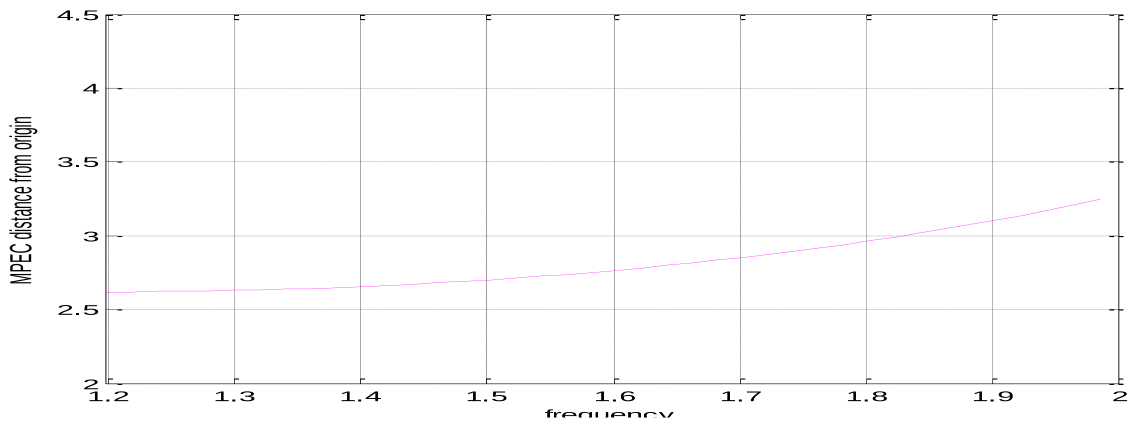

Figure 4. MEPC displacement of horn antenna with frequency

Figure4 shows the plots for radial displacement of MEPC from origin (horn aperture plane) over the frequency band of operation. The estimation of MEPC for the horn antenna which is nearly its half power beam width. The intersecting points of all one degree angular sectors, over this angle. It can be observed the intersect points form a cluster and are distributed around the antenna center point of reference. The intersect point is the MEPC of the antenna in the plane of measurement for a given angle and polarization. The MEPC for the horn was determined with different frequencies. The increasing MEPC distance as increasing the frequency. The MEPC location is better accuracy at higher frequency. The estimated MEPCs location in Cartesian coordinates (x, y) as well as its radial distance in electrical units for different frequencies. The Phase pattern of horn antenna at 1.5 GHz as shown in figure 5

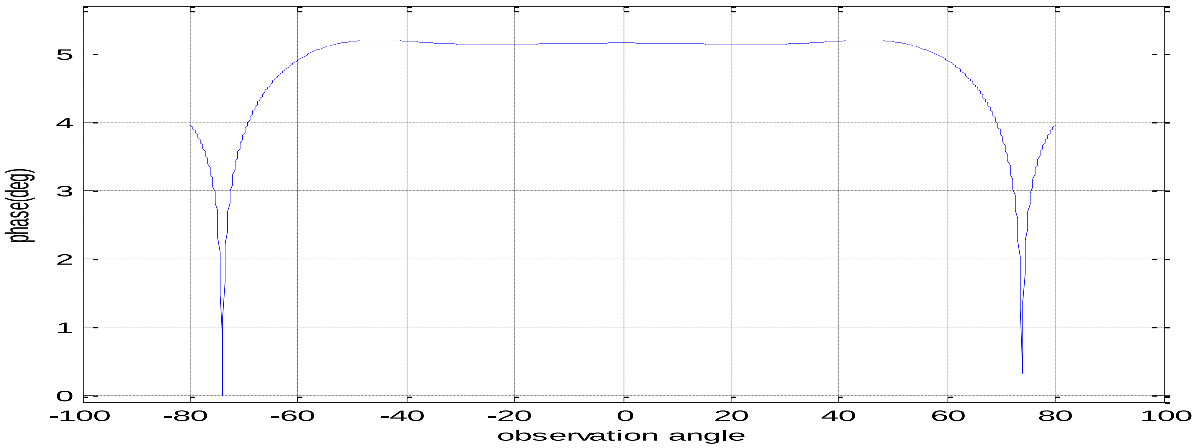

Fig. 5. Phase pattern of horn antenna at 1.5 GHz

As the size of wavelengths is increased, the phase error increases, giving the horn a wider radiation pattern. Keeping the beam width narrow requires a longer horn (smaller flare angle) to keep the phase error constant. The increasing phase error limits the aperture size of practical horns to about 15 wavelengths; larger apertures would require impractically long horn. The estimated of phase pattern at various angles for horn antenna beam at a given frequency of 1.2GHz.

IV. CONCLUSION

In this paper, horn antenna and patch antenna estimate exact the location of phase centers. These are less complex and easily determine the mean electrical phase center of horn and patch antenna in Cartesian coordinates. This methods demonstrated high repeatability and its employability for different types of antennas. It works for a wide spectrum of frequencies and does not require signals directly from satellites. This 2-D MEPC estimation scheme can be easily extended for estimation of MEPC of antenna in 3-D space as well.

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