Monopole Antenna for 406MHz Cospas Sarsat Search and Rescue Beacon

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October 3, 2019

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***Abstract*— This paper presents the analysis details of monopole antenna for Emergency Position Indicating Radio Beacon (EPIRB) for Cospas Sarsat search and Rescue System. Change in antenna radiation pattern with respect to variations in antenna length, the height of antenna from the antenna ground, ground plane dimensions and beacon floating levels are simulated and analyzed in detail. Test results of an optimum configuration that can meet Cospas Sarsat specifications for 406MHz EPIRB are also presented.**

***Keywords* —Beacon, Cospas Sarsat, EPIRB, 406MHz**

I. Introduction

Cospas Sarsat is an international consortium for search and rescue applications, which utilizes satellites for the identification of distress and initiation of rescue operations. Cospas Sarsat has three segments, namely user segment, space segment, and control segment. User segment includes different types of user devices like Emergency Position Indicating Radio Beacon (EPIRB) for Maritime applications, Personal Locator Beacon (PLB) for personal applications like trekking and Emergency Locator Transmitter (ELT) for aviation applications. Space segment includes dedicated Low Earth Orbit (LEO) and Medium Earth Orbit (MEO) satellites as well as satellites with Cospas Sarsat payloads like INSAT 3D satellite of India. The control segment includes Local User Terminals (LUTs), Mission Control Centres (MCCs), and Rescue Coordination Centres (RCCs) etc. which are globally distributed. The detection of distress signals and passing on the details of distress to the respective rescue agencies are done by LUTs and MCCs [1].

All the three user devices have their own specifications requirements and operate at 406MHz. EPIRB is meant for marine applications, especially in ships and boats. On distress, the device is activated either manually or automatically, on contact with marine water. The device has to operate for 48 hours continuously on activation. EPIRB transmits important information like distress location identified by its inbuilt GPS receiver, unique registered serial number, type of device etc.

In order to use the user devices internationally, it has to obtain the necessary certification by Cospas Sarsat. As part of this certification process, the device has to undergo a series of test conditions specified by Cospas Sarsat. Most of the Beacons available in the market use monopole antenna for the transmission of 406MHz signals. These antennas vary in length, antenna ground plane dimensions, the spacing between the antenna and antenna ground plane and Beacon floating levels [2]-[4]. This paper analyses the effect of variations of these parameters on the gain pattern of the monopole antenna in detail.

II. Requirement specifications for EPIRB antenna

EPIRBs have to meet the antenna gain and Effective Isotropic Radiated Power (EIRP) requirement in the specified test conditions put up by Cospas Sarsat [5]. The transmitted power specification of the device is 37dBm±2dBm.

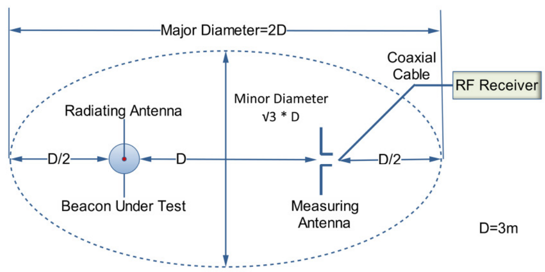


Fig. 1. Test area specifications

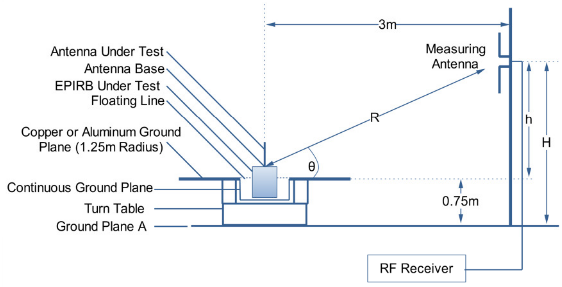


Fig. 2. Setup for test condition with ground plane

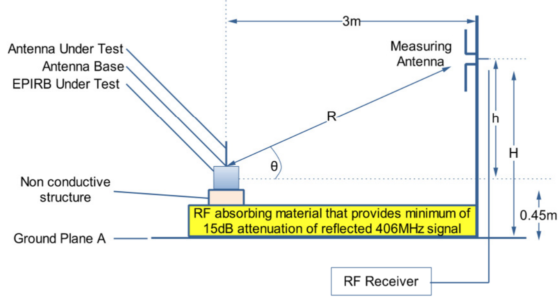


Fig. 3. Setup for test condition without ground plane

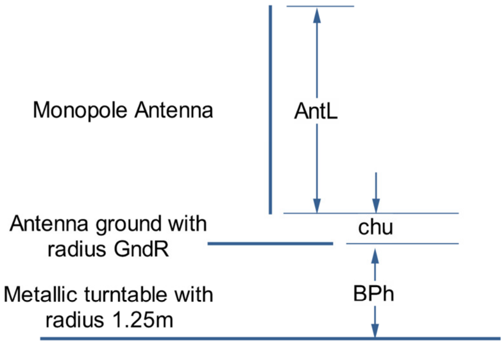
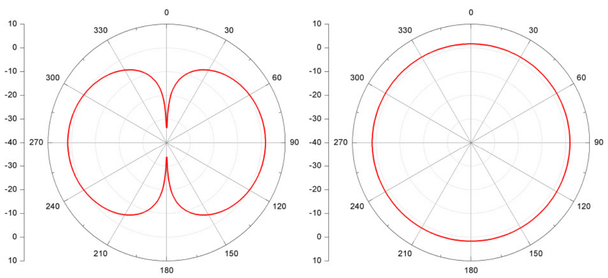


Fig. 4. Configuration for simulation and variable design parameters

The EIRP requirement is from 32dB to 43dB in the case of test condition with ground plane and 30dB to 43dB in the case of test condition without ground plane. The accuracy levels for EIRP measurement are specified in [5].

Antenna gain can vary from -3dBi to +4dBi for the test condition with ground plane and -5dBi to +4dBi in the case of test condition without ground plane. These antenna gain specifications are for elevation angles from 10degrees to 50degrees for entire 360degrees azimuth angles. The gain is measured for elevation angles at 10degree interval from 10 to 50degrees. Azimuth angles are incremented at 30degrees interval in the case of test condition with ground plane and at 90degrees interval for test condition without ground plane [6].



(a) (b)

Fig. 5. (a) E Plane and (b) H Plane gain pattern of the antenna

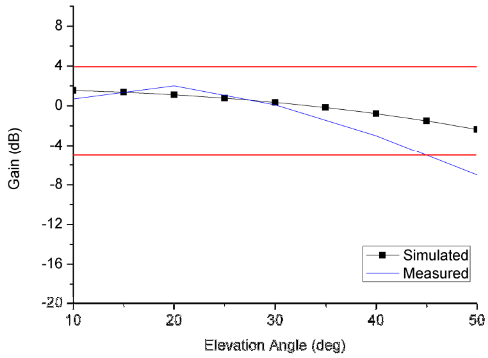


Fig. 6. Simulated and measured gain for test condition without ground plane with nominal design values

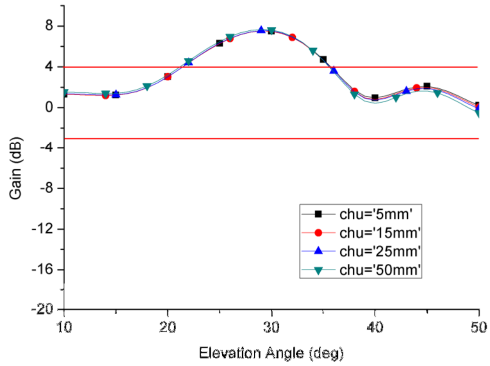


Fig. 7. Gain variation for different values of ‘chu’

In the former case, 90% of the points should be within the specification limits while in the latter case only 80% of points are needed to be within limits.

III. TEST SETUP

A minimum elliptical test area as shown in Fig. 1 should be kept free from any obstructions for carrying out antenna measurements. Beacon Under Test (BUT) and Measurement Antenna (MA) are placed at 3m apart horizontally. BUT and MA should have a minimum clearance of 1.5m from the perigee points of the clear elliptical area with major axis 2D and minor axis √3D where D is 3m. The measurements are carried out in anechoic chamber to avoid interference due to reflections.

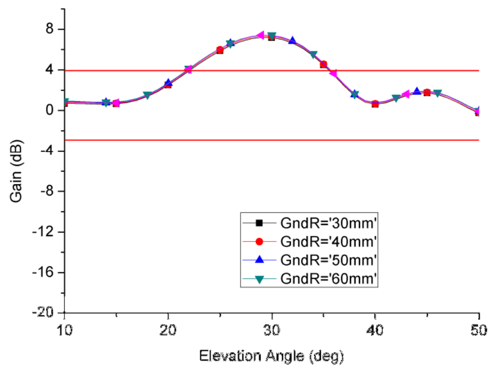


Fig. 8. Gain variation for different values of ‘GndR’

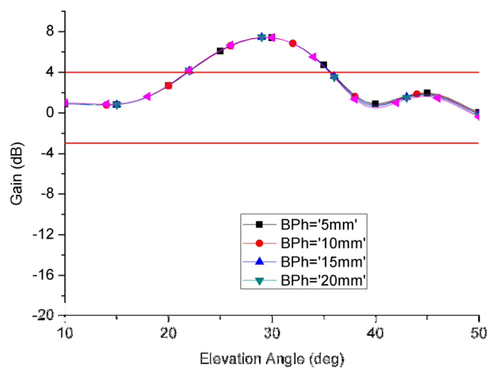


Fig. 9. Gain variation for different values of ‘BPh’

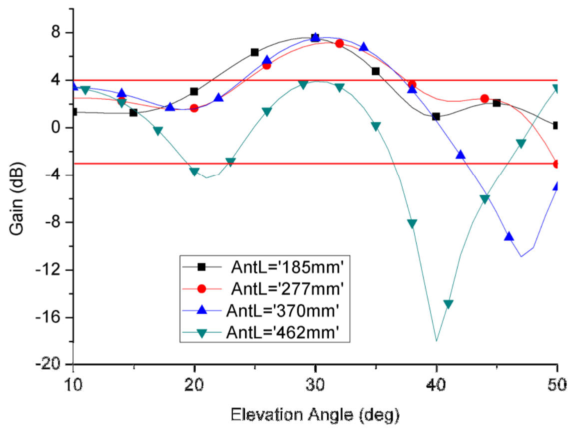


Fig. 10. Gain variation for different values of ‘AntL

Setup for test condition with ground plane is shown in Fig 2. The BUT is placed on a metallic turntable with 1.25m radius and 0.75me height. The Beacon is put inside the centre cavity of the turntable such that the floating level of the beacon is in plane with the top surface of the turntable. The ground plane is made continuous inside the cavity. The measurement antenna which is connected to the RF receiver, is placed at a horizontal distance of 3 metres away from BUT on a mast. The antenna elevation is varied to take measurements at different elevation angles.

Fig. 3 shows the setup for test condition without ground plane. Here the metallic floor is covered with absorbers and BUT is place at 0.45m above ground on a nonconductive stand.

IV. SIMULATION, RESULTS AND DISCUSSION

Simulation of the antenna with the test setup is performed in Ansys HFSS software. The configuration and variable design parameters are shown in Fig. 4. Here ‘AntL’ is the length of the antenna, ‘chu’ is the gap between antenna and its ground plane, ‘GndR’ is the radius of the circular ground plane, and ‘BPh’ is the height difference between beacon floating level and antenna ground plane. Nominal design values of these parameters are: AntL=185mm (λ/4), chu=15mm, GndR=50mm, and BPh=10mm.

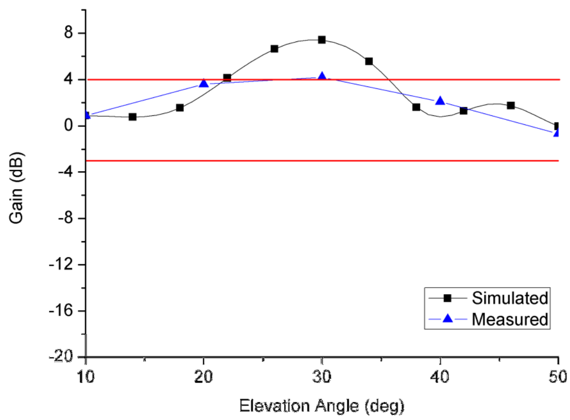


Fig. 11. Simulated and measured gain for test condition with ground plane with nominal design values

Typically a quarter wave (λ/4) monopole antenna has an omnidirectional radiation pattern [7]. Fig.5 shows the E plane and H plane patterns of the antenna along with antenna ground for nominal design values. The simulated and measured gain values for elevation angles from 10degrees to 50 degrees is shown in Fig. 6 and this meets the gain requirements for the test condition without ground plane.

Simulations are carried out by varying the design parameters for the test condition with ground plane. The gain variations with ‘chu’ for ‘AntL’ of 185mm is shown in Fig.7. Fig.8 and Fig. 9 shows gain variations with ‘GndR’ and ‘BPh’ respectively. Here also the antenna length is maintained at λ/4. The variation in gain pattern with different antenna lengths (AntL) namely 185mm (λ/4), 277mm (1.5 λ/4), 370mm (2 λ/4), and 463mm (2.5 λ/4) are shown in Fig. 10.

The simulation results show that the impact on the gain pattern with variations in ‘chu’, GndR’, and ‘BPh’ is very much negligible. But the change in antenna length has a significant effect on gain pattern. As the antenna height becomes 2.5 λ/4, a deep null is formed at around 40degree elevation angle and a small null is formed at around 20 degree. These nulls can result in more number of out of limit points with respect to specifications.

The simulated and measured gain values for the test setup with ground plane and with nominal design values are shown in Fig. 11. This shows that the measured gain values of the antenna with nominal design values meets all the gain requirements for both of the test setup specifications. Usually the measured gain will be 2 to 3dB less than the simulated values.

V. CONCLUSION

406 MHz monopole antenna for EPIRB application is simulated and analysed for various design conditions. The analysis shows that variations in height of antenna from antenna ground, antenna ground dimensions and beacon floating levels have a negligible impact on gain pattern. Any change in antenna length affects the pattern significantly and a deep null is formed at around 40degree elevation angle when the antenna height becomes 2.5 λ/4. Measured results show that the antenna with nominal design parameters meets all the gain requirements for test conditions with and without ground plane, as specified by Cospas Sarsat.

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