Proceedings of ISAP'04, Sendai, JAPAN

3B3-6

A Low Profile Design of Lower Pitch Angle Helix with Conical Taper-end

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1. Introduction

Axial mode helices have been used as a wide band circularly polarized antennas due to its compact and light configuration. Typical helix design is that the pitch angle α is within the range of 12deg to 14deg [1]-[3] which is optimum values to generate axial mode operation. This range of pitch angle is called as a normal pitch angle helix (NPH) in this paper. In usual axial mode design, the number of turns is over ten so that length of helix is more than two wavelength. Increasing the length sometimes cause the problem for the sake of satellite onboard applications. Applying lower pitch angle is convenient to decrease the height of the helix, while mode operation of axial mode is degraded and this is not used in practice.

This paper proposes a new lower pitch angle helix that pitch angle is about half of NPH for an approach of decreasing the height of helix. In general, lower pitch angle helix is not suitable for axial mode operation so that good performance cannot be obtained. In order to overcome the degradation of axial ratio, a conical taper-end is addressed. The concept of the taper-end has also been proposed for improving the axial ratio for NPH in which the number of taper-end turns are less than two turns [4],[5]. However, improvement of axial ratio has been difficult in case of LPH by using only two turns. It reveals that increasing number of taper-end is shown to be effective for LPH and results in obtaining almost same performance as well as NPH. As a result, height of LPH can be achieved as about half of that against normal pitch angle helix with broad bandwidth.

Further, axial ratio bandwidth of LPH has also investigated with different pitch angles and a new indication of low profile design has been derived, that is, optimum design of pitch angle considering bandwidth is smaller than that of NPH.

A LPH have been designed and manufactured in the L-band and its qualification test results are also indicated for satellite use. Effective performance has been confirmed through design and test results.

2. Configuration of LPH with taper-end and design method

Fig.1 shows a configuration of lower pitch angle helix (LPH) with conical taper-end mounted on a ground plane. In this figure, N1 is a number of uniform turns and N2 is that of conical taper turns. This conical taper-end is addressed to improve the axial ratio performance and its effectiveness is calculated using Moment method. Fig. 2 shows the axial ratios with varying the number of taper-end turns N2 in cases of α=7 and 13deg. In the case of α=13deg., good axial ratio can be obtained independent of turns N2. On the other hand, in the case of α=7deg, sufficient axial ratios cannot be obtained when N2=0, while axial ratio can be improved drastically by increasing N2. It reveals that increasing number of turns is shown to be effective for LPH and results in obtaining almost same axial ratio as well as NPH. Fig.3 shows the axial ratio bandwidth with changing β. In the case of β=3deg., a number of turns are required to obtain good axial ratio. On the contrary, the case of β=20deg., improvement can be seen with small turns, however, sufficient axial

ISBN: 4-88552-207-2 C3055©IEICE

ratios of less than 1dB cannot be obtained. It is found that there is a suitable angle of about β=10deg., to obtain good axial ratio with keeping low profile.

Fig.4 shows the axial ratio bandwidth with varying α in the condition of obtaining same gain at 12dBi, and the number of turns N2 are adjusted to obtain good axial ratio for each α. The bandwidth of axial ratio is enhanced in linear approximately with increasing α in the range of α > 6deg. Fig.5 shows the height of helix with changing α in the condition of obtaining same gain. It is found that the height of helix is increased exponentially. From Figs.4 and 5, the ratio of bandwidth against height with changing α can be calculated in Fig.6. A new design indication introducing the definition of bandwidth/height for obtaining broad bandwidth has been derived that there is optimum bandwidth ratio against the height, that is α=7 to 8deg. It is taken interest that these values are smaller than well known design of α=12deg. to 14deg.

3. Fabrication and test results

A LPH with conical taper-end that parameters are α=7, N1=5 and N2=5 has been fabricated and tested in the L-band. Fig.7 shows the axial ratio in frequency response. Measured data are in good agreement with calculated ones, and propriety of design of this LPH with conical taper-end have been verified. This broadness is sufficient for application of satellite communication. Figs. 8(a),(b) show the radiation patterns considering transmitting and receiving frequencies and good agreement between calculated and measured patterns can be seen. Low cross polarizations of less than –25dB at theta = 0 deg. were obtained

Fig.9 shows the photograph of a engineering model of LPH with conical taper-end. Qualification tests of have been performed to verify survivability against to vibration, shock, temperature cycling and high power handling and no degradation were found [6].

4. Conclusions

A new LPH with conical taper-end and its design method have been proposed. It is revealed that conical taper-end is effective for improving performance for LPH and this leads to use lower pitch angle helix in practice. Further, a new design indication of pitch angle has been derived that optimum bandwidth ratio of axial ratio against the height is found to be smaller than that of NPH. This finding is effective for reducing height of helix, and about half height compared to that of NPH has been realized.

A LPH have been designed and manufactured in the L-band for satellite communication and effectiveness has been confirmed.

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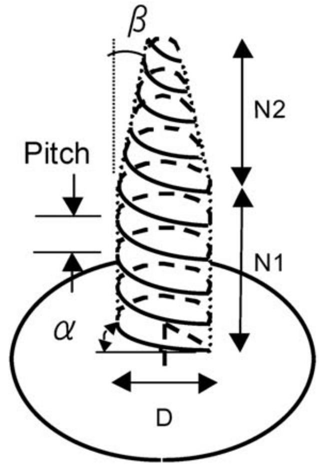


Fig.1 Configuration of LPH with conical taper-en

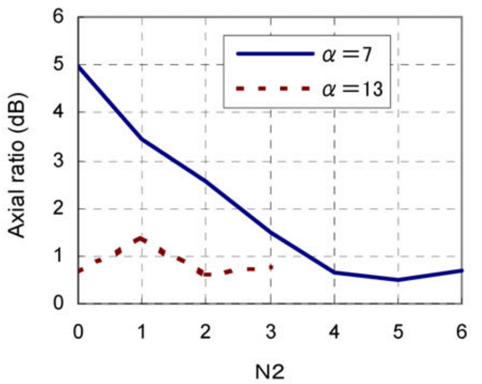


Fig.2 Axial ratio versus number of turnsN2 with changing α (β=10 deg.)

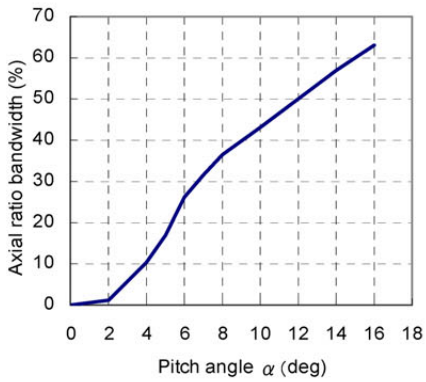


Fig. 4 Axial ratio bandwidth with varying pitch angle α.

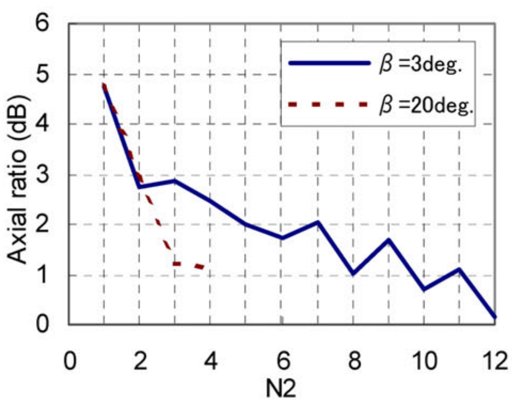


Fig.3 Axial ratio versus number of turns N2 with changing β. (α=7 deg.)

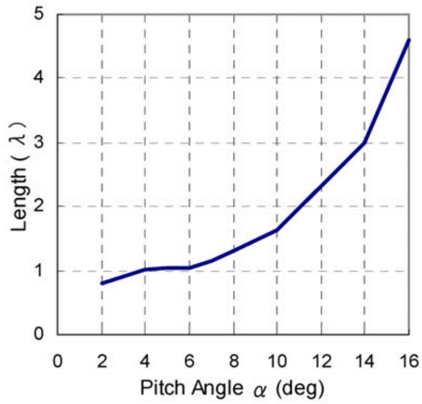


Fig.5 Height of helix with varying pitch angle α.

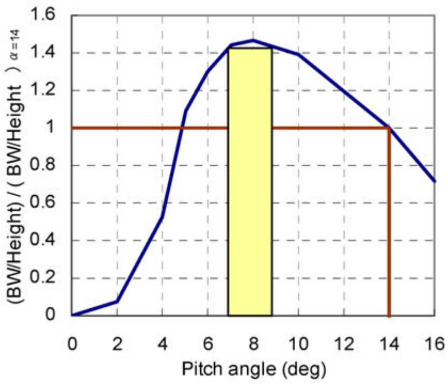
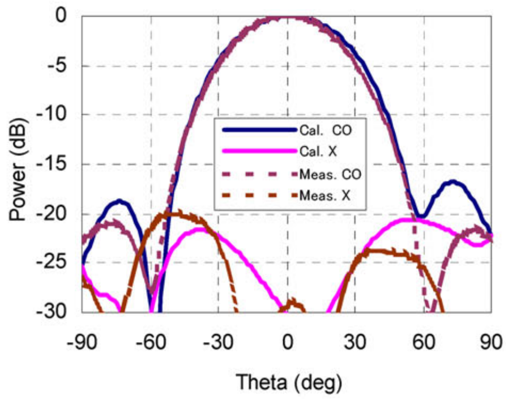


Fig. 6 Bandwidth against height with changing pitch angle α.



(a) 0.96fo

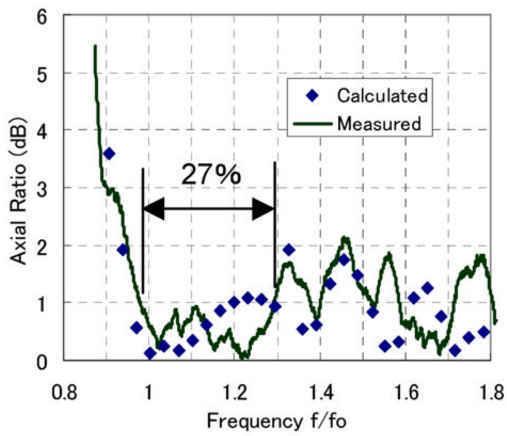
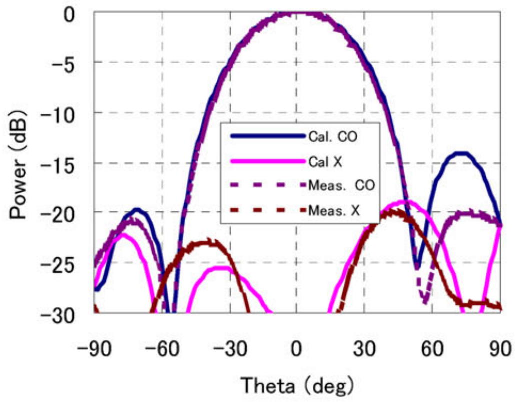


Fig.7 Axial ratio bandwidth in frequency response.



(b) 1.04fo

Fig. 8 Radiation patterns

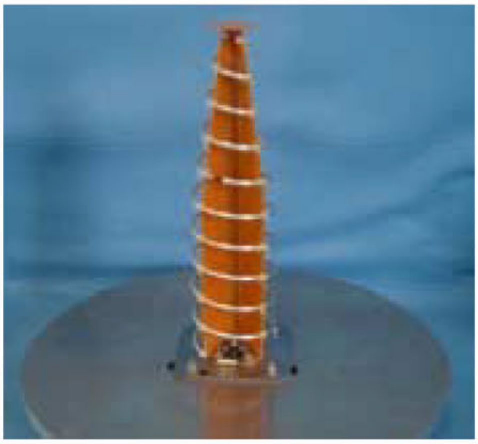


Fig.9 Photograph of LPH with conical taper-end