Proceedings International Seminar of Aerospace Science and Technology 17th SIPTEKGAN -2013, 24: 179-184

THE INFLUENCE OF HELIX ANTENNA TURNS TOWARD BEAMWIDTH ON MICRO-SATELLITE

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Abstract

Helix antenna operates in two main modes, normal mode and axial mode. LAPAN A1 micro-satellite (LAPAN TUBsat) uses Helix antenna with a beamwidth of 70 degrees and 3.13 turns. The purpose of this paper is to determine the effect of turns on the micro satellite beamwidth, so that a comparison can be used as a reference for designing the Helix antenna in future micro satellites.

Key Word *: Helix Antenna, turn, beamwidth, gain.*

1. Introduction

An antenna (or aerial) is an electrical device which converts electric power into radio waves, and vice versa. Helix antenna can serves as a transmitter only, or receiver only or both. Examples of Transmitter only are television and radio transmitter antenna AM / FM and others. Examples of Receiver only are radio receiver antenna AM / FM, TV antenna etc.

Some common terms in antenna theory, are radiation pattern, gain (strong emission), polarization, and so forth. Radiation pattern refers to the directional dependence of the strength of the radio waves from the antenna. Circular patterns or straight patterns can be formed by an antenna. While the gain is a key parameter which measures the antenna's efficiency. Polarization of an antenna is the orientation of the electric field of the radio wave with respect to the Earth's electric surface and is determined by its physical structure and orientation.

The antenna is a crucial communication device on terrestrial communication systems and also in space.

LAPAN A1 Satellite (LAPAN-TUBsat) Helix antenna has a beamwidth of 70 degrees, a gain of 8.5 dBi, 3.13 turns. What influence do the number of turns have on the beamwidth and gain of this antenna on micro satellites, will be simulated and discussed on in this paper.

1.1. Goals

The Calculation simulated here to determine how much influence the turns towards the micro satellite beamwidth, hence can be used as a reference for future micro-satellite.

2. Theory

Axial mode helix antenna was first introduced by John. D Kraus in 1947. In the axial mode or end-fire helix the antenna functions as a directional antenna radiating a beam off the ends of the helix along the antenna's axis. This mode provides up to 15 dB gain and high bandwidth ratio of about 1.78:1. In this operation mode, emission becomes very narrow as the number of turns on the helix increases[3)].

Helix antenna is an antenna that has a three-dimensional shape. It resembles the shape of a helix antenna with a particular diameter and range of turns. Helix antennas can be operated in two modes, namely, the Transmission mode and Radiation Mode. At the Radiation mode in turn has two modes, namely, axial mode and normal mode.

In the axial mode, helical dimensions are at or above the operating wavelength. Antenna produces radio waves with circular polarization.

2.1. Helix Characteristics

Helix antenna in Figure 2.1 has some important parameters, namely: the antenna diameter (d), around the helix / circumference (C), spacing between turns (S), pitch angle) □ (, axial length (A)[4)].

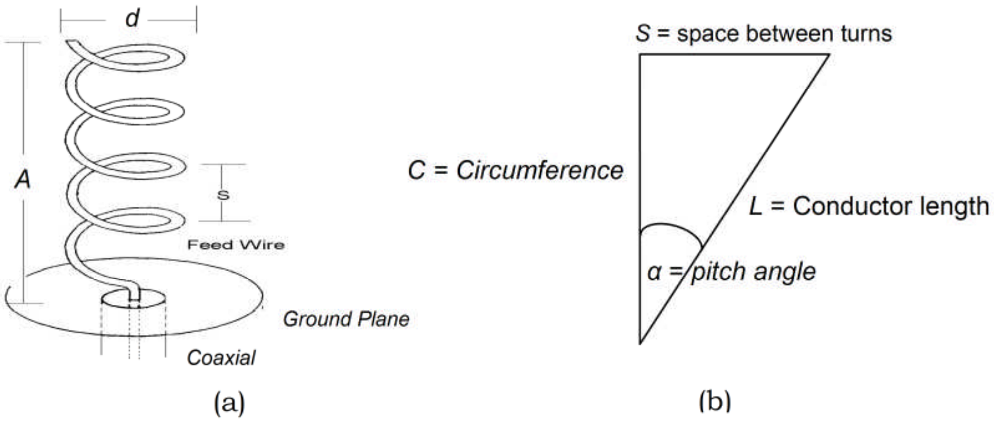

Fig. 1. (a) Helix antenna geometry, (b)Relation betweencircumference (C), diameter(d), pitch angle (□), spacebetweenturns(S) and the Helix length between loop(L)

Several important parameters of the antenna beamwidth and gain are a function of the number of turns (n), and the distance between the turns (S), and frequency.

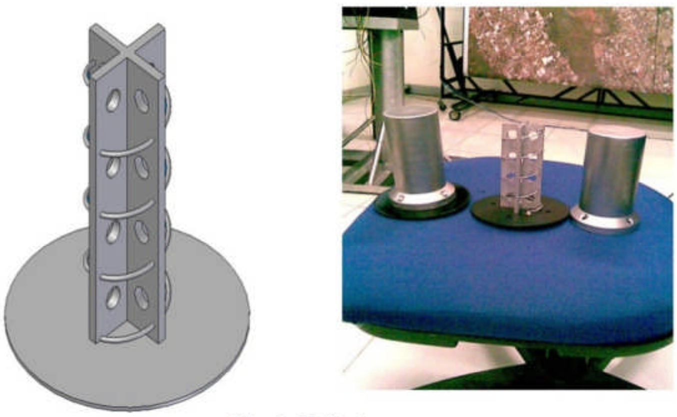

Fig. 2. Helix Antenna

2.2. Radiation Pattern

The radiation pattern is a graphical overview of the relative field strength transmitted from or received by an antenna. The radiation pattern of the antenna takes one frequency, one polarization and one part of the plot. Pattern is usually given in the form of a straight line with a polar or dB strength scale. Normalized value of the total radiation pattern of a helix antenna is calculated by Eq. (1)[3)]

$$E = \left(\sin \frac{90^0}{N} \right) \frac{\sin\left(\frac{N\psi}{2} \right)}{\sin\left(\frac{\psi}{2} \right)} \cos\theta \qquad (1)$$

with,

N = number of turns,

φ = angle,

$$\Psi = 360^0\left[S_\lambda(1-\cos\theta)+\left(\frac{1}{2N}\right)\right],$$

$S_\lambda = S/\lambda$,

$S =$ space between turns (*cm*),

$\lambda =$ wavelength (*cm*).

2.3. Beamwidth

Beamwidth is the maximum angle with vertical, horizontal or circular polarization. The higher the antenna gain, antenna capability in focusing electromagnetic waves will be more narrowed and focused to the object. On the other hand, a small antenna will emit a wide angle and also transmit a smaller gain.

Half-power (-3 dB) helix antenna beam width is measured directivity antenna with the following equation:

$$HPBW = \frac{52}{C_\lambda\sqrt{NS_\lambda}} \quad \text{(degree)} \tag{2}$$

2.4. Gain

Gain relates the intensity of an antenna in a given direction to the intensity that would be produced by a hypothetical ideal antenna that radiates equally in all directions (isotropically) and has no losses. By using equation (2-3) the following will be produced when the amount of gain for an axial mode helix antenna is almost ideal, without any loss of directivity and gain.

$$G = 11{,}8 + 10\log\left(\frac{C^2NS}{\lambda^2}\right) \quad (dBi) \tag{3}$$

with,

C = *Circumference*

N = number of turns

S = space between the turns

The higher antenna gain, the capability in focusing electromagnetic waves will be more narrow and focused to the object. Large antenna generates large gain and transmit a narrow angle, on the other hand antenna direction shall be more precise on the object. For more details, small-sized antenna will emit a wide transmission angle and also a smaller gain.

3. Methode

Methodology used on composing this paper as follows

- Literature studies regarding Helix antenna either by reading books or through the Internet.
- Simulated calculations using the antenna software by entering equations needed.

This research methodology can also be seen as a flowchart below :

Fig. 3.Research Methode

4. Analysis And Research

Below are comparation table between Gain and Beamwidth towards the number of turns.

Table 1. Comparation between Gain and Beamwidth

N (Jumlahlilitan)	Gain (dBi)	Beamwidth (Derajat)
3	9.03	71.5
3.13	9.22	70
3.5	9.70	66.2
4	10.3	61.9
4.5	10.8	58.4

And below are the comparation shown in the form of graphics.

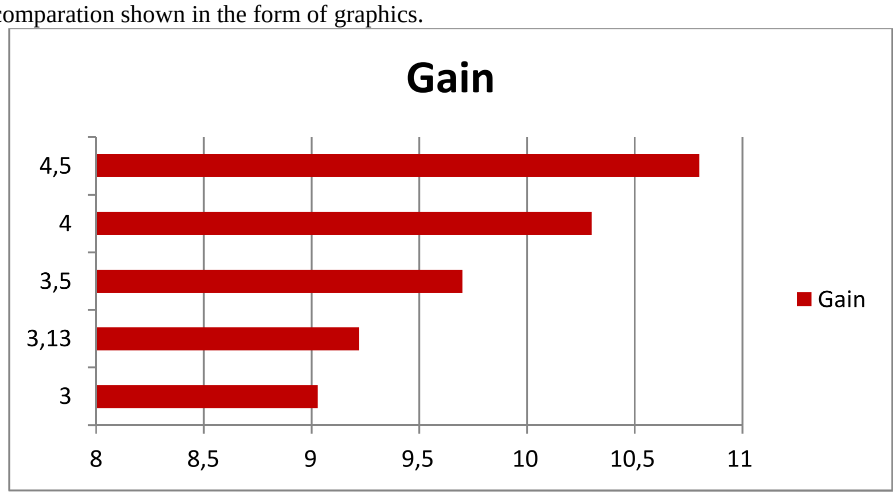

Fig. 4.Gain Graphic

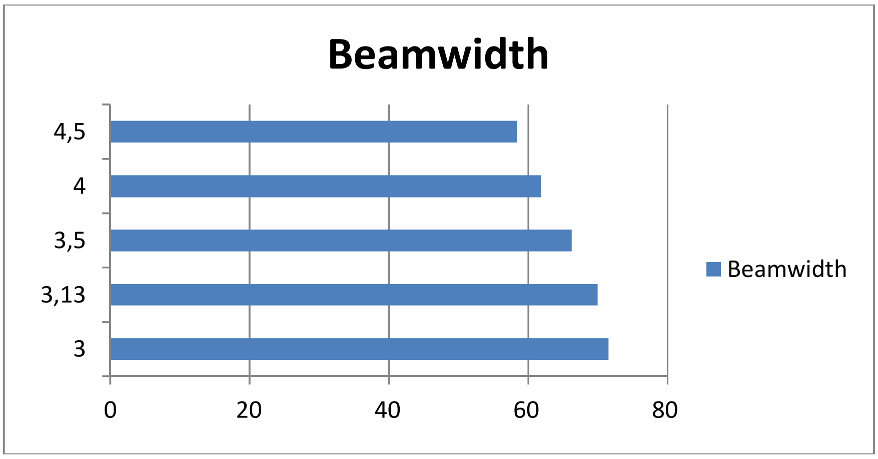

Fig. 5.Beamwidth Graphic

The Fig.4 and Fig. 5, shows that as the number of turns on Helix antenna increases, the gain increases and beamwidth decreases. Based on LAPAN A1 satellite datasheet, the beamwidth is 70 degrees, with a gain of 8.5 dBi. From the results of simulation calculations, to get a beamwidth of 70 degrees number of the turns required is 3.13 and the resulting gain is 9.22 dBi.
This research was begun by building the prototype of The Helix antenna used on micro-satellite LAPAN A1 which was built in Germany, the antenna had been tested in the laboratory of Institut Teknologi Bandung (ITB) by using Helix antenna with four turns. The test result showed that these are not much difference compared to the micro satellite LAPAN A1 antenna data sheet.

The Helix antenna testing procedures can be seen in Fig. 6 and Fig. 7 plot below:

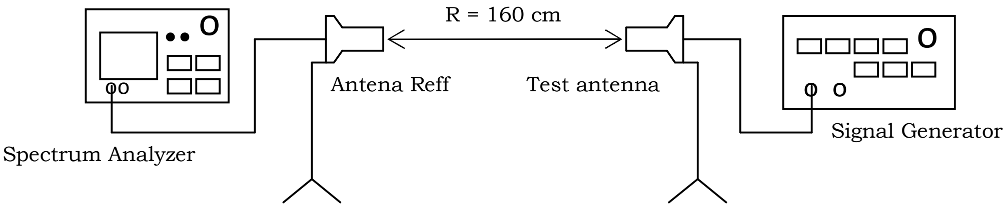

Fig. 6.Beamwidth Test Procedure

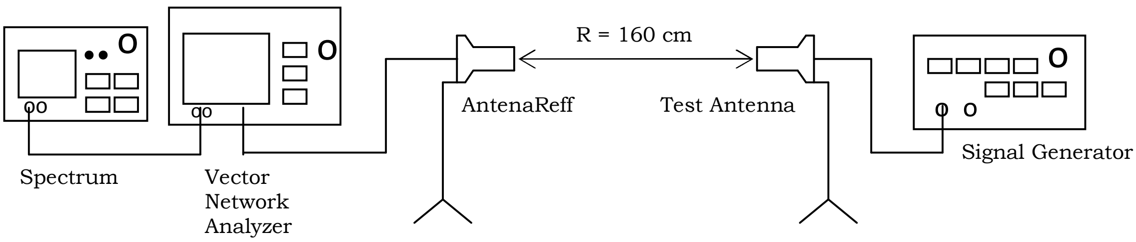

Fig. 7.Gain Test Procedure

The next test, which was on this research paper, was to determine the required amount of turns when the required beamwidth was at seventy degrees by using an antenna simulation software, it was not possible at the moment to test one by one of turns in the laboratory as the number of Helix antennas built should also be more than one.
There is no ideal number of turns, it depends on the size of the required beamwidth. The more the number of turns the Helix antenna dimensions would be even greater. It is sometimes important to consider the fact that the antenna is to be used on micro satellites, hence the size cannot be too big.

5. Conclusion

1. The amount of turns on Helix antenna depends on the required beamwidth hence the data transmission can be maximized.
2. Beamwidth affects the coverage area, the larger the beamwidth then the coverage will be more broadly.
3. The more amount of turns will caused increased gain and decreased beamwidth.

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