

Minimizing yagi-uda radiosonde receiver antenna size using minkowski curve fractal model

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Abstract. This paper discusses Yagi-Uda antenna design for radiosonde earth station receiver. The design was performed by using Minkowski curve fractal model to reduce physical dimension. The antenna design should fulfil the following requirements: work on frequency of 433MHz, match to the 50 Ohm of radiosonde characteristic impedance, the expected gain is higher than 10 dBi, VSWR is smaller than 2 and the expected bandwidth is higher than 10 MHz. Antenna design and evaluation were conducted by using MMANA-GAL simulator. The evaluation of the designed antenna shows that the Yagi-Uda antenna designed by using Minkowski curve model successfully reduces antenna size up to 9.41% and reduces number of elements about 33%.

1. Introduction

Radiosonde is a metrological equipment to measure atmospheric data such as pressure, altitude, latitude, temperature, wind direction and velocity. These data are measured by sensors attached to a balloon and are sent to the earth station [1]. In order to maintain communication reliability between the radiosonde and the earth station, the receiving antenna should fulfill gain and bandwidth requirements.

One of the commonly used antennas is Yagi-Uda. To achieve the expected gain, a Yagi-Uda antenna should have sufficient number of elements and physical dimension. This paper proposes antenna enhancement by using fractal technique proposed in [2] to optimize physical dimension and gain performance of the Yagi-Uda antenna for used as the earth station receiver antenna, to detect and receive signal from radiosonde. Multiband characteristic as well as physical dimension reduction are the advantages of the technique.

2. Yagi-Uda Antenna

Shintaro Uda from University of Tohoku in Sendai Japan invented the Yagi-Uda antenna. The antenna contains of director, driven and reflector elements as depicted in Figure 1 [3].

Driven element works as power receptor that is connected to transmission line. Reflector reflects the escaping signal and returns to driven element. The director directs the electromagnetic wave to driven element. Each element size is measured by using the following formulas: 0.4886λ , 0.4614λ and 0.43λ , where λ is the expected wavelength [4].



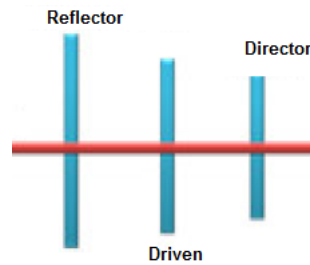


Figure 1. Yagi-Uda Antenna

3. Minkowski Curve Model

Minkowski curve belongs to a German mathematician Herman Minkowski. The curve modifies is suitable for monopole antenna by using fractal function with several iteration as shown in Figure 2 [5].

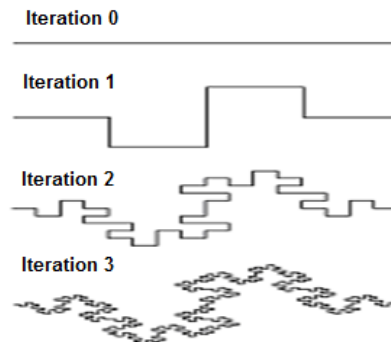


Figure 2. Minkowski geometrics

The geometric is determined by using the following equation [5] where L is the total length, N is number of geometric segments, r is number segments per iteration, h is wire size, and n is the iteration.

$$L = h \left(\frac{N}{r} \right)^n = h \left(\frac{8}{4} \right)^n \quad (1)$$

4. Research Method

There are two fractal techniques; random and deterministic. A deterministic Minkowski curve is chosen as the fractal improvement in this paper. The Yagi-Uda antenna is designed by using aluminum wire with diameter of 4 mm, 8.6 mm and 9 mm operating in 433 MHz. The expected performances are gain ≥ 10 dBi, VSWR ≤ 2 and bandwidth ≥ 10 MHz.

Design was conduction by using MMANA-GAL simulator [6]. MMANA-GAL is an open source simulator created by Alexander Schewelev (DL1PBD), Igor Gontcharenko (DL2KQ), and Makoto Mori (JE3HHT) [6].

5. Result and Analysis

Figure 3 shows the designed Minkowski curve Yagi-Uda antenna. The initial design of reflector results $L=0.34$ m and $L_1 = L_2 = L_3 = L_4 = L_5 = L_6 = L_7 = L_8 = 0.0425$ m. The driven and director elements are calculated accordingly. The numbers of directive elements are optimized to produce the expected performances.

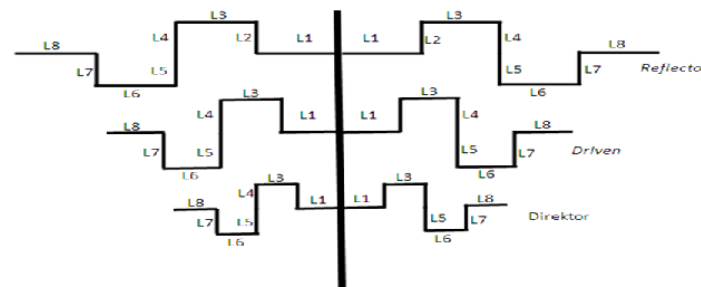


Figure 3. Designed Minkowski Yagi-Uda antenna

Table 1 shows some antenna adjustments to produce gain $\geq 10\text{dBi}$, VSWR ≤ 2 and bandwidth $\geq 10\text{MHz}$. For 4 mm antenna diameter, the required physical elements for both Yagi-Uda and Minkowski Yagi-Uda are 6 elements. But the later produces higher gain and bandwidth. For 8.6 mm diameter, Minkowski Yagi-Uda requires only 4 elements, lower than Yagi-Uda (6 elements). The same case is applied for 9 mm diameter.

Table 1. Aluminium wire 4 mm, 8.6 mm and 9 mm.

Number of elements	Antenna	Diameter	Gain (dBi)	BW (KHz)	VSWR
6	Yagi-Uda	4 mm	10.04	18332.3	1.85
6	Minkowski Yagi-Uda	4 mm	10.23	25019.8	1.94
5	Minkowski Yagi-Uda	4 mm	9.89	20465.2	1.99
4	Minkowski Yagi-Uda	4 mm	9.02	22390.9	1.98
6	Yagi-Uda	8.6 mm	10.47	33217.9	1.86
6	Minkowski Yagi-Uda	8.6 mm	11.41	15271.5	1.99
5	Minkowski Yagi-Uda	8.6 mm	11.03	23449.7	1.98
4	Minkowski Yagi-Uda	8.6 mm	10.11	18846.2	1.81
6	Yagi-Uda	9 mm	10.42	31456.4	1.90
6	Minkowski Yagi-Uda	9 mm	11.48	14886.5	1.94
5	Minkowski Yagi-Uda	9 mm	11.13	22222.8	1.96
4	Minkowski Yagi-Uda	9 mm	10.17	18476.4	1.78

Beside number of element reduction, the length of each element of Minkowski Yagi-Uda decreases. Figure 4 shows one of Yagi-Uda element reduction. Length reduction achieves up to 9.41%.

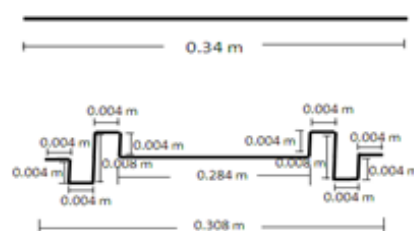


Figure 4. Reflector length reduction

6. Conclusion

This paper has proposed Minkowski curve fractal improvement on Yagi-Uda antenna used in radiosonde earth station. The first iteration of Minkowski curve results number of elements as well as element length reduction. Minkowski increases gain of an aluminium wire Yagi-Uda antenna with diameter 8 mm. For 8.6 mm and 9 mm diameter, Minkowski reduces number of elements by two elements (33%). Element length reduction achieves up to 9.41%.

Future work may implement the fractal technique to remote radiosonde antenna as the size reduction will reduce balloon load.

References

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