One-Point-Fed Yagi-Uda Loop Array with a Quarter-Wave Transformer

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1. Introduction

For a one-point-fed circularly polarized Yagi-Uda loop array, there is the noticeable effect of the feed cable on the radiation characteristics [1]. Due to this effect the frequency for the measured minimum axial ratio (AR) is shifted from the one calculated. The input resistance of this antenna is very high and the input reactance is about 0Ω at the center frequency. Thus it is not matched to the coaxial feed cable.

In this paper, a quarter-wave transformer is introduced to improve radiation and matching characteristics of the antenna. The quarter-wave transformer consists of parallel lines and decreases the unbalanced current flowing on the coaxial feed cable. The characteristics are investigated numerically and experimentally. For the 3-element array the VSWR and the AR are lower than 2 and 2dB, respectively. The gain of about 8dBi and the front to back ratio (FBR) of 8dB are obtained in the measurement.

2. Antenna configuration

A Yagi-Uda loop array with a quarter-wave transformer is shown in Fig.1. Antenna #1 (circumference L1) is a driven element, antenna #2 (circumference L2) is a reflector and antenna #3 ~ #N (circumference L3 ~ LN) are directors. The element spacings are d2 ~ dN. The parallel lines are spaced at a distance DG. The open point on the loop is set on the y-axis.

In the calculation, it is assumed that the gap length of the driven element is infinitesimal and the wire radius is 0.005λ. In the experiment, the diameters of the loop wire and transformer are 1.8 mm and they are made of copper. The operating frequency is 1.5GHz (λ=20cm).

3. Results

The moment method computer program in [2] is used to calculate the antenna characteristics.

In Fig.2 the VSWR characteristics of the 3-element array are shown when L1=1.38λ, L2=1.17λ, L3=0.75λ and d2=d3=0.25λ. These parameters are chosen to obtain the minimum AR in the operating frequency. The spacing of the parallel lines is adjusted to obtain the minimum VSWR. The VSWR bandwidth (≤2) of 16% is obtained for the calculated and measured data. In Fig.3 the gain and the AR are shown where the calculated results do not include the effects of the feed cable and the transformer. The effect of the unbalanced current on the feed cable is decreased by the transformer and the frequency shift for the AR becomes small. The measured AR is 1 ~ 2dB over the calculated VSWR bandwidth (≤2). The measured gain fluctuates against the frequency. For the measured gain, the approximate curve (a polynomial of order 5) calculated using the experimental values agrees well with the calculated gain. Fig.4 shows the radiation pattern in the y-z plane. The asymmetry of the E_θ component is caused by the effect of the feed cable. The FBR of about 11dB are obtained. The half-power beamwidth of 70° is obtained where the AR is less than 2dB.

Fig.5 shows the gain versus the number of elements. The array parameters is shown in Table.1. The gain increases in proportion to the number of the directors and is about 10dBi for the 6-element array.

Fig.6 shows the characteristics of the 3-element array when parameters are chosen experimentally to obtain the lowest AR. The AR bandwidth (≤2dB) of 11% is obtained. The gain is about 8dBi over the bandwidth (AR≤2dB) where the approximate curve is the polynomial of order 5. The radiation pattern in the y-z plane is shown in Fig.7. The field is decomposed into a right-hand (E_R) and left-hand (E_L) circular polarization component. The half-power beamwidth of 65° is obtained where the AR is less than 2dB. The FBR is about 8dB.

4. Conclusion

The characteristics of a one-point-fed circularly polarized Yagi-Uda loop array with a quarter-wave transformer is investigated numerically and experimentally. The transformer decreases the unbalanced current flow on the feed cable and matches the input impedance of the loop with the feed cable (50Ω). By choosing the parameters appropriately, the low AR and high gain are obtained.

References

[1] Y. Ojiro and K. Hirasawa, "One-Point-Fed Circularly Polarized Yagi-Uda Loop Array," Proc. of IEEE AP-S Int. Symp., Vol.4, pp.1875-1878, June, 1995.

[2] K. Hirasawa and M. Haneishi (ed.), "Analysis, Design, and Measurement of Small and Low-Profile Antennas," Chapter 2, Artech House, Inc., Boston (1991).

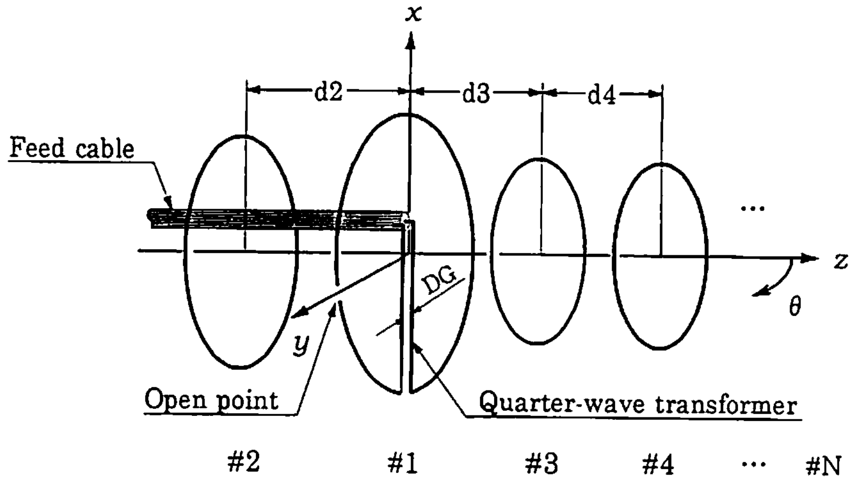

Fig. 1 Antenna configuration

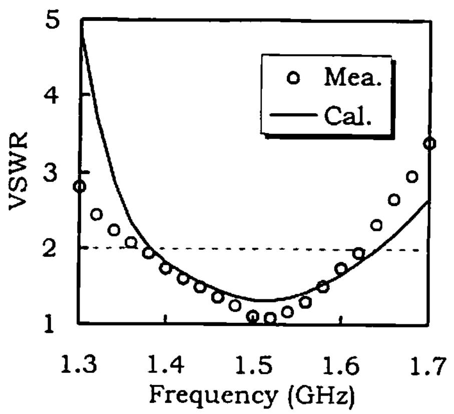

Fig. 2 VSWR against frequency DG=4.5mm

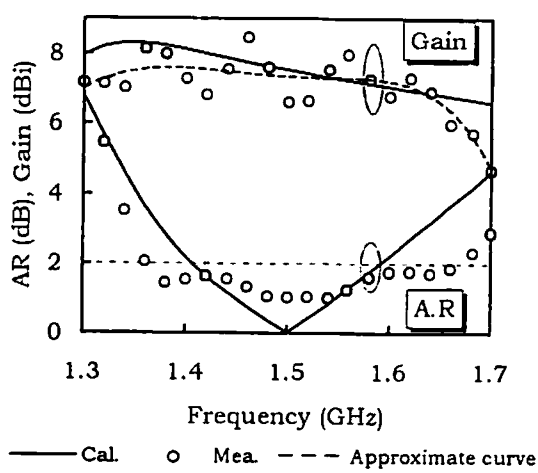

Fig. 3 AR and gain against frequency

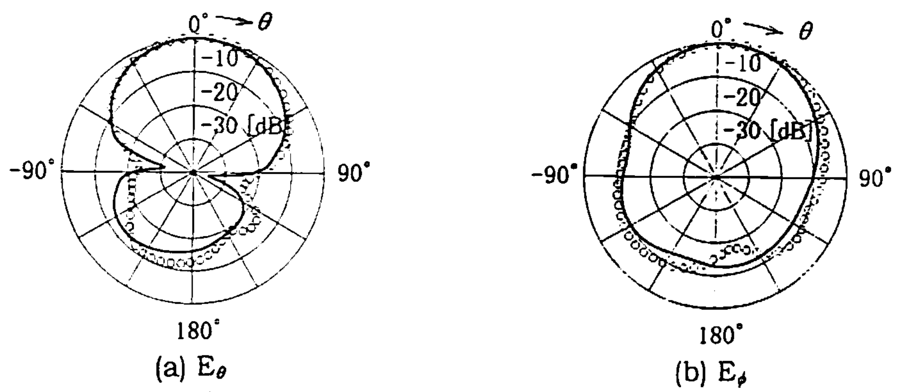

Fig. 4 Radiation pattern in the *y-z* plane

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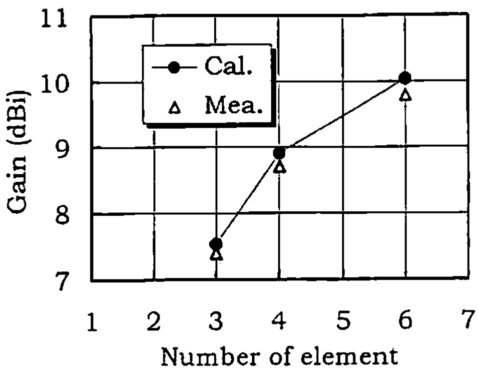
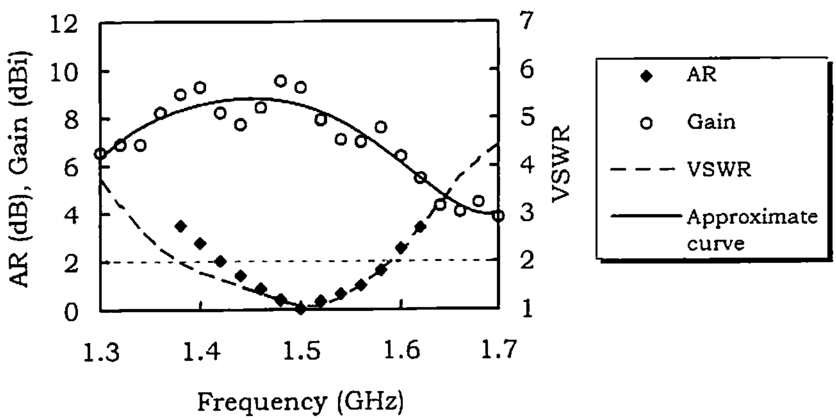


Fig. 5 Gain against the number of elements

Table. 1 Array parameters

	3-elem	4-elem	6-elem
L1/λ	1.38	1.36	1.37
L2/λ	1.17	1.12	1.14
L3-L6/λ	0.75	0.85	0.85
d2-d6/λ	0.25	0.25	0.25



L1=1.37λ, L2=1.10λ, L3=0.90λ, d2=d3=0.25λ

Fig. 6 Characteristics of 3-element array (Parameters are chosen experimentally)

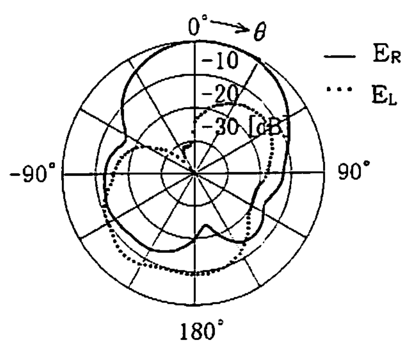


Fig.7 Radiation Pattern in the *y-z* plane