AN INVESTIGATION OF THE ARRAY OF STACKED CIRCULAR-LOOP ANTENNA

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INTRODUCTION

Stacked circular-loop antenna is well known as one of high gain antenna as well as circular-loop antenna.
NHK [1] has reported stacked circular-loop antenna of reflector type composed of a driven stacked circular-loop and reflector board used for UHF TV Broadcasting as one example of practical application.
KAGOSHIMA [2] analyzed for the first time a stacked circular-loop antenna by means of solving the integral equation for the current function with the aid of Fourior series expantion.
However, the end-fire array antenna composed of stacked circular loop elements is not yet considered on the characteristics sufficiently and accuratly by analysis and experiments, and so we carried out numerical computation for the end-fire array of 2-element stacked circular-loop by Fourier series expansion in a manner similar to that of a loop antenna analysis [3]. The computed results are compared with the experimental results in order to convince the validity of this method, and we investigated with radiation characteristics of 8-element YAGI-UDA array antenna composed of a driven stacked loop and parasite loop.

NUMERICAL METHOD

Consider on the array of stacked circular-loop antenna to arrange parallel to each other with centers on the Y axis and to drive in the X-Z plane as shown in Fig. 1 .

The integral equation for the current function $I_j(\varphi_j')$ on the element surface is given by

$$\sum_{j=1}^{4}\int_0^{2\pi}\{F_{ij}\cdot I_j(\varphi_j')\}\,d\varphi_j' = \frac{V_i}{\delta\varphi_i}\cdot U_i(\varphi_i) \qquad \text{——— (1)}$$

where F_{ij} is the Green's function proportional to electric field that current on the i th or j th make on the surface of i th element, V_i is the driving point voltage on loop of the i th and $U_i(\varphi_i)$ is a function equal to unity at the driving point and zero elesewhere.

As a result of using the method of Fourier series expansion(3) in order to solve the simultaneous integral equation (1), we obtained the following simultaneous equation which contains unknown current $I_j^n(n=0, \pm1, \pm2, \ldots)$ on loop surface after the same easy manipulation;

$$\sum_{l=-\infty}^{\infty}\left[Z_{ii}^{m}I_i^{l} + \sum_{j=1}^{4}Z_{ij}^{m,l}\cdot I_j^{l}\cdot\delta_{ij}\right] = V_i\cdot\frac{\mathrm{Sin}(m\delta\varphi_i/2)}{m\delta\varphi_i/2}\cdot e^{jm\pi\delta_i} \text{—(2)}$$

where $\delta_{ij}=0$ (i=j), $\delta_{ij}=1$ (i=j), $\delta_i=0$ (1,2), $\delta_i=1$ (i=3,4) .
Z_{ii}^{m} , $Z_{ij}^{m,l}$ is the self and mutual impedance matrix.
The current on the j th element obtained from simultaneous equation (2) is given by

$$I_j(\varphi_j') = \sum_{n=-\infty}^{\infty} I_j^n e^{-jn\varphi_j'} \qquad j=1,2 \qquad \text{——— (3)}$$

and some other radiation characteristics can be computed by using the current equation (3).

EXPERIMENTS

We conducted an experimental investigation on a 2-element array in order to confirm the results of this numerical method.
Fig. 2 shows the comparison of the computed results and experimental results of current distribution, input impedance and radiation patterns. Measured values agree well with computed results except for the neighbourhood of $kb_j=1.0$.
The amplitude of the current distribution is the largest at $\varphi=0°$ and the smallest at $\varphi=90°$. Input impedance shows resonant characteristics at $kb_j=1.0$. A half power angle decreases with increasing the distance of loop D_{ij}, but the side lobe increases.

Fig. 3 shows counter curves of directive gain for axial direction toward parasite and opposite parasite. It may be observed that, if array elements are spaced with 0.2λ at the center frequency 620 MHZ, the largest directive gain for axial direction toward parasite is 13.2 dB at kb_j =0.9 and the most suitable condition of directive gain for axial direction opposite parasite at D_{ij}= 0.5λ is the case of kb_j=1.0 at h_{ij}=0.25λ~ 0.27λ .
Fig. 4 shows radiation characteristics of 8-element YAGI-UDA array composed of a driven stacked circular-loop and parasite circular-loops. It may be confirmed that works as wide bandwidth and high gain antenna having a half-power angle of 38° in H plane, F/B of 16 dB and actual gain of about 10 dB and gives larger actual gain by about 4.5 dB than a YAGI-UDA dipole array antenna of the same length.

REFERENCE

[1] K.Endo,Y.Endo and H.Okamura, "Stacked loop antenna for UHF Television Broadcasting", ITE of Japan,18,5,p281,May 1964.

[2] K.Kagoshima,T.Sekiguchi and N.Inagaki, "Characteristics of the array of off-axial circular loop antennas" ,IECE of Japan, AP,VOL.56-B, No7, July 1973.

[3] S.Ito,N.Inagaki and T.Sekiguchi, "An investigation of the array of circular-loop antennas" , IEEE Trans. AP-19,No.4,p469 July 1971.

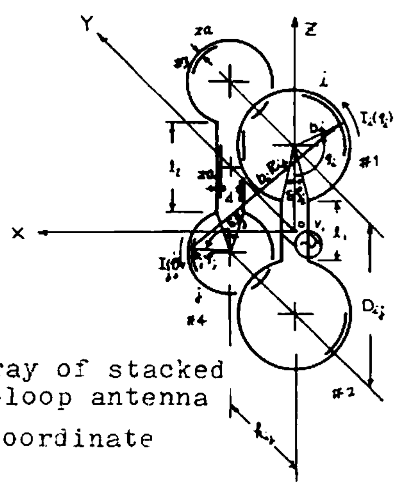
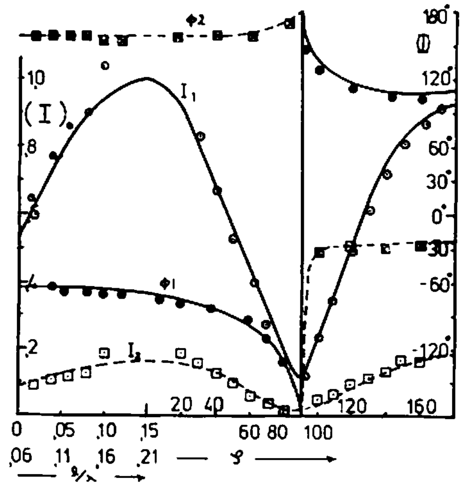
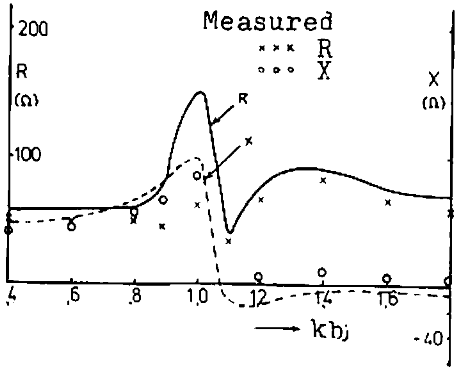


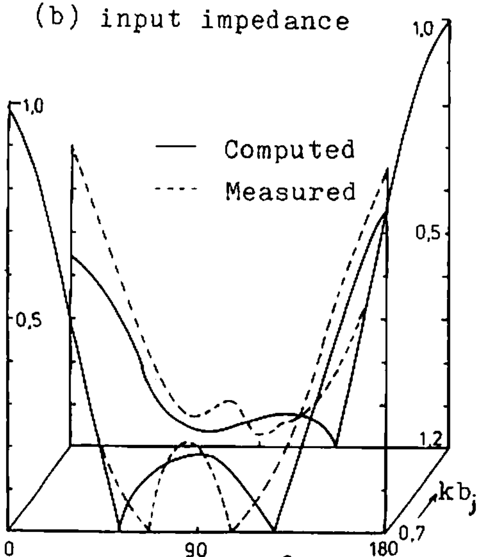
Fig.1 array of stacked circular-loop antenna and its coordinate system.



(a) current distribution

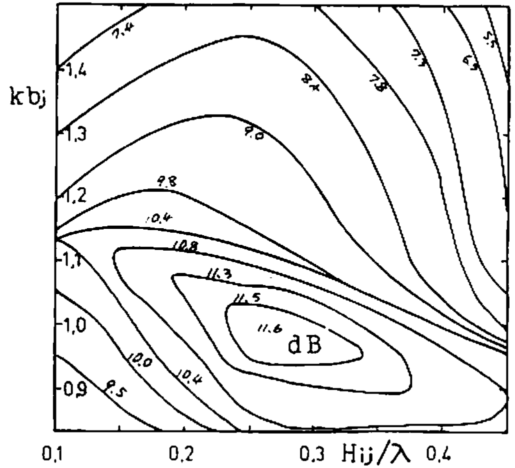


(b) input impedance

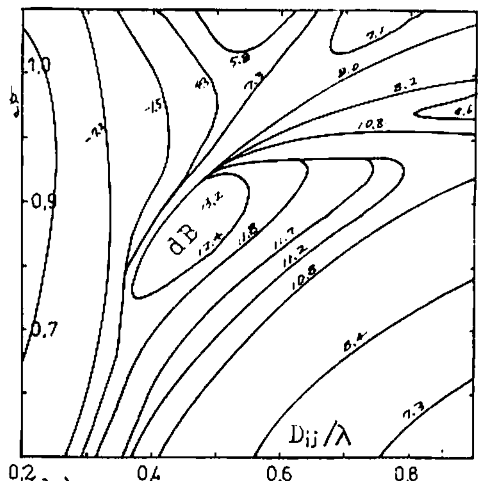


(c) radiation field patterns

Fig.2 comparison of computed and measured results.

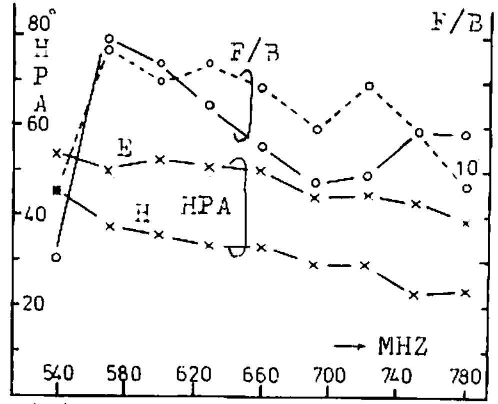


(a) toward parasite

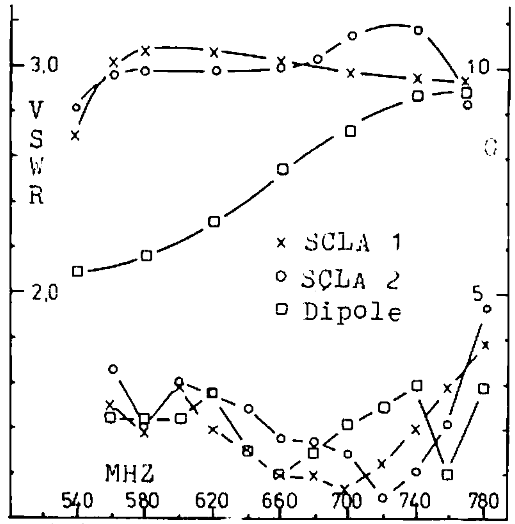


(b) opposite to parasite

Fig.3 contour curves of directive gain.



(a) HPA and F/B



(b) VSWR and actual gain

Fig.4 radiation characteristics of 8 elements SCLA.