CHARACTERISTICS OF UHF TV BAND LOG-PERIODIC STACKED-CIRCULAR LOOP ANTENNA

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INTRODUCTION

The Log-periodic structure antenna has advantages of unidirectional directivity and frequency-indipendent characteristics . For these reasons, a number of studies have been made on this type . However, most of the studies reported so far have hardly refered to the elevation of antenna gain, except Carrel [1] and Sekiguchi [2].

In this paper, High gain UHF TV Band Log-periodic Stacked-Circular Loop Antenna (LPSA) is proposed and a mathematical model of the LPSA is developed with analyzing current distribution as well as radiation characteristics and shown that high gain and wide band width characteristics can be obtained by Log-periodic structure parameter τ= 0.9. The frequency-independent characteristics are also observed in all region of UHF TV Band.

THEORETICAL AND EXPERIMENTAL RESULTS

LPSA configuration is depicted in Fig.1. Log-periodic stracture parameter τ and σ are coefficient for radius b of circular loop and spacing d between loop elements, respectivity, as follows

$$\tau = b_i / b_{i-1} \quad , \quad \sigma = d_i / 2\pi b_{i-1} \qquad \cdots\cdots (1)$$

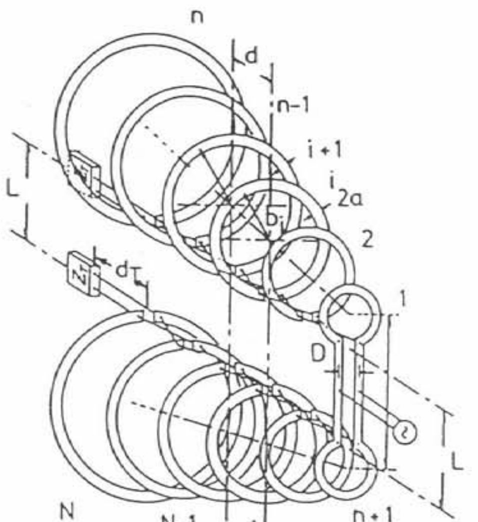


Fig. 1 LPSA configuration

A mathematical model of LPSA is shown in Fig.2. In loop element circuits, the current matrix $[I_j]$ on the base of j th loop element circuit is given by

$$[I_j] = \sum_{n=0}^{\infty} [I_j^n] = \sum_{n=0}^{\infty} [Y_j^n][V_j], \qquad \cdots\cdots (2)$$

where $[Y_j^n]$ is admittance matrix with loop elements.

The current matrix $[I_f]$ on the transmission line circut is shown by

$$[I_f] = [Y_f][V_f], \qquad \cdots\cdots (5)$$

where Y_f and V_f are the admittance matrix on the transmission line and the voltage matrix, respectively.

Since the loop elements and transmission line circuits are connected in parallel, The input current matrix $[I_i]$ can be written as :

$$[I_i] = [I_j]+[I_f]= \sum_{n=0}^{\infty} [Y_j{}^n][V_j]+[Y_f][V_f]. \qquad \cdots\cdots (6)$$

yielding $[V_j]=[V_f]=[V_i]$,
thus, input voltage matrix $[V_i]$ is :

$$[V_i]=\{ \sum_{n=0}^{\infty} [Y_j{}^n]+[Y_f] \}^{-1} [I_i], \qquad \cdots\cdots (7)$$

where input current matrix $[I_i]$ is :

$$[I_i]=[I_1,0,0,\cdots,0]. \qquad \cdots\cdots (8)$$

Since the driving point current matrix $[I]$ of LPSA is symmetric with respect to driving point, $[I]$ can be calculated in the following form,

$$[I]= 2[Y_b][V_i] = 2\{ \sum_{n=0}^{\infty} [Y_j{}^n]+[Y_f] \}^{-1} [Y_b][I_i], \qquad \cdots\cdots (9)$$

where admittance matrix on the twin-lead between stacked loop elements $[Y_t]$ is given as :

$$[Y_b]= \begin{bmatrix} -jY\cot k(L/2) & jY\operatorname{cosec} k(L/2) \\ jY\operatorname{cosec} k(L/2) & -jY\cot k(L/2) \end{bmatrix} . \qquad \cdots\cdots (10)$$

Some other radiation characteristics can be also computed by using the current equation (9).

Fig.3 shows the directive gain G and VSWR for parameter τ, as a function of parameter σ. According to this curve, it should be noted that the optimum condition for high gain and low loss is realized by $\tau=0.9$ at $\sigma=0.16$ to 0.20.

Fig.4 shows the relative amplitude and phase of element base current as a function of element number. The element base currents in the active region (the region of frequency-indipendent characteristic) has a peak in the element which is somewhat shorter than a wavelength and moves along loop element as frequency is changed.

A plot of input impedance versus frequency is shown on the Smith Chart of figure 5. It has a tendency to draw a circle in the region of VSWR=2.0 .

Examples of the relative field patterns are shown in Fig.6. Active region can be observed in the range 440 MHZ to 860 MHZ and measured patterns agree well with computed results. The patterns in active region show relatively good characteristics that half-power angle is about 70° in E-plane and 45° in H-plane, but definite patterns deterioration has occured at the high frequency range than the upper limit frequency 850.5MHZ .

The measured radiation characteristics at $\tau = 0.9$, $\sigma = 0.18$, $L/\lambda=0.35$ $Z=200\ \Omega$ and element number N= 6 and 10 are shown in Fig.7.

CONCLUSION

A mathematical model of LPSA was provided at first. From this model, the properties of the loops were described by an impedance matrix which relates the voltage and current at the base of each loop. Each loop elements were excitated by a transmission line circuit, it was also described by a impedance matrix. Loop elements and the transmission

line circuts were joined and driving point matrix of LPSA were obtained.
From this quantities, some other radiation characteristics were studied and the UHF TV Band LPSA at N=10 was found that works as a half-power angle $\Phi_H=45°$ in H-plane and $\Phi_E=70°$ in E-plane, F/B=15dB, VSWR=2.3, actual gain G=9 dB and active region W_a=300 MHZ.

REFERENCES

[1] R.L.Carrel;Analysis and desigin for the Log-periodic dipole antenna, Tech.rep.No.52,Engr.res.Lab,univ.Illinois(1961).
[2] B.Rojarayanont,T.Sekiguchi;Characteristics of Log-periodic circular -loop antenna,Trans.,IECE Jpn.,Vol.J60-B,No.8,p583 (1970).

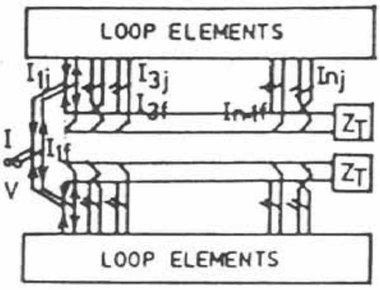
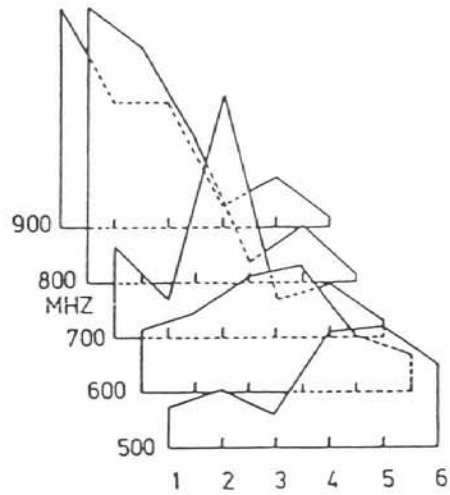


Fig. 2 a mathematical model of LPSA



(a) relative amplitude

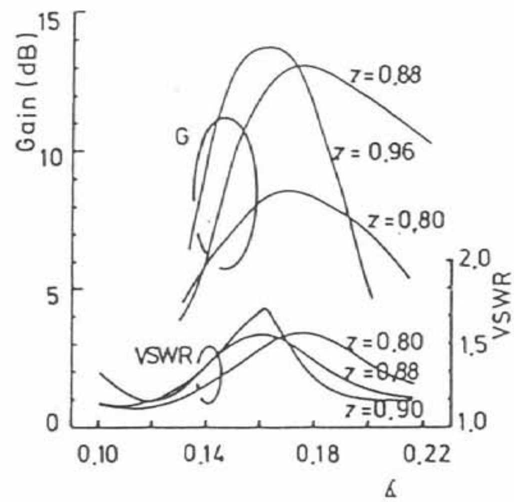
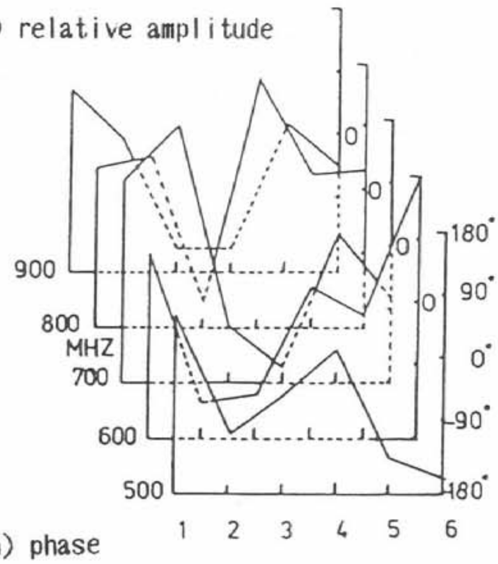


Fig. 3 directive gain G and VSWR



(b) phase

Fig. 4 relative amplitude and phase of element base current

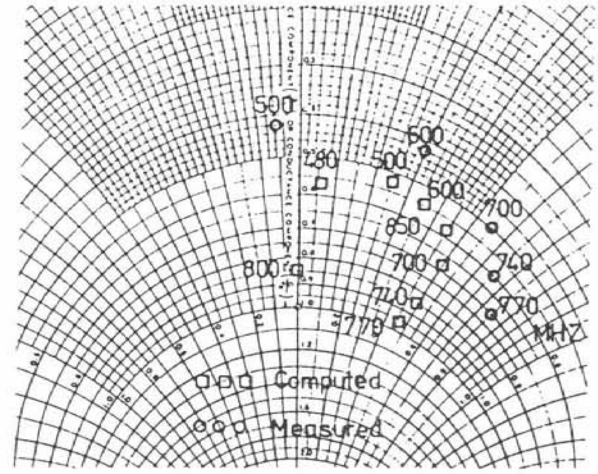
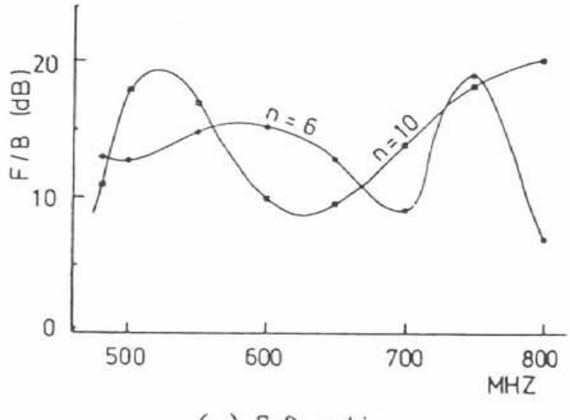
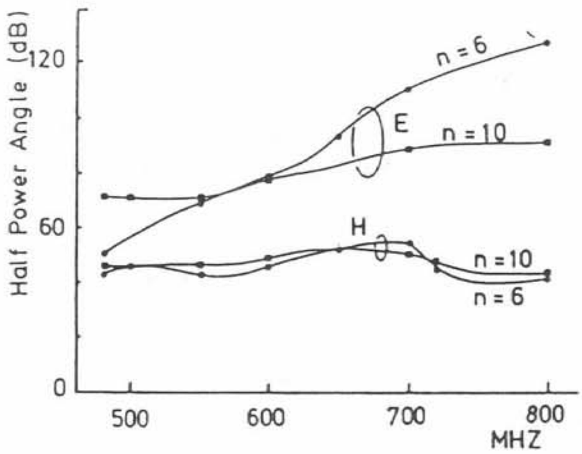


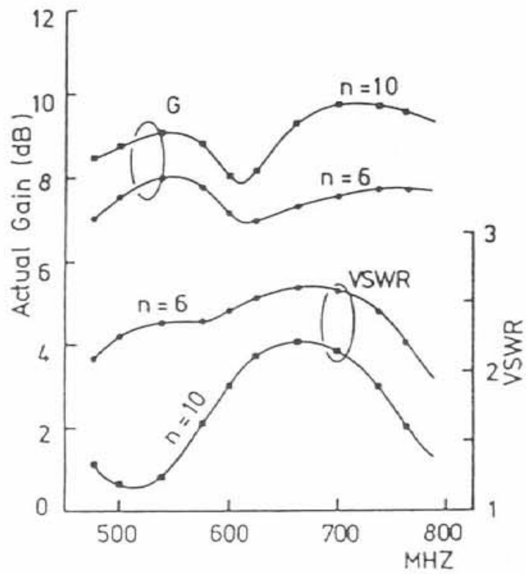
Fig. 5 input impeadance



(a) F-B retio



(b) half power angle



(c) actual gain

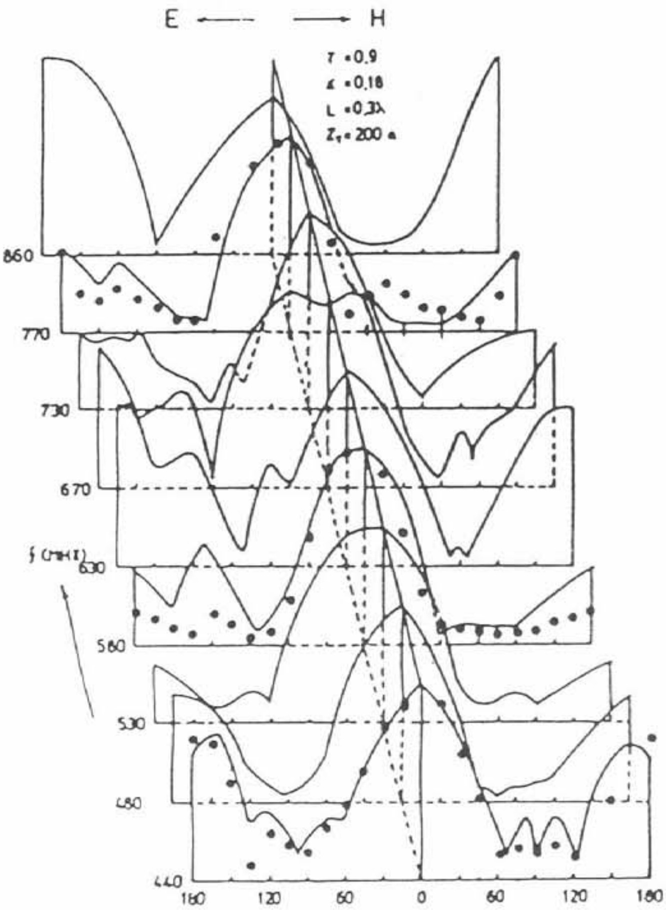


Fig. 6 relative field patterns

Fig. 7 radiation characteristics