1-II B6 AN ACTIVE FERRITE ANTENNA WITH PARAMETRIC EXCITATION

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1. Introduction

An active ferrite antenna has been studied and a considerable improvement in sensitivity (gain in terms of S/N) over the conventional ferrite antennas has been obtained. Although ferrite antennas have long been used as one of the typical antennas of small size, the remarkable increase of its sensitivity would hardly be expected, since sensitivity of the ferrite antenna depends upon dimensions and the performance of the ferrite material, which might not be significantly improved at the present state of the art. One way to solve the problem may be the application of the integration technique, that is to combine an antenna and active devices in an unified structure with an inseparable form. As an active device, parametric excitation is incorporated into antenna structure and power transfer between signal and pumping signal, which follows Manley-Rowe's theorem, is performed within the antenna itself.

2. Theory and experiments

The principle of this antenna is the power transfer between received signal and pumping signal through time-varying inductance, resulting in amplified signal at the load of the output; permeability of the ferrite antenna core is varied timely by applying the pumping current to it.

The treatment of this type of antenna is not very simple, since both antenna and parametric circuitry are functionally combined in an unified form, so that they cannot be treated separately as in the usual system. In this paper, an example of the fabricated models in the experiments shown in Fig.1 is taken into considration and the antenna system is expressed by a simplified equivalent circuit shown in Fig.2. The signal voltage V_s of ω_s (ω: angular frequency) induced in an antenna structure having radiation resistance R_a is taken as the source of this system. This signal is pumped by the signal of ω_p, so that the amplified signal of ω_2 ($= \omega_p - \omega_s$) is obtained at the load R_ℓ. Z_1 and Z_2, respectively, are the input and output impedances of the parametric circuits. The signal is amplified through a time-varying inductance $L(t)=L_0+2L_1 \times \cos \omega_p t$, where L_0 and L_1, respectively, denote the constant and variable inductances at ω_p. For the down converter operation, the voltage-current relations between the signal and output can be expressed as follows.[1]

$$\begin{pmatrix} V_s \\ V_2^* \end{pmatrix} = \begin{pmatrix} j\omega_s L_0 & j\omega_s L_1 \\ -j\omega_2 L_1 & -j\omega_2 L_0 \end{pmatrix} \begin{pmatrix} I_s \\ I_2^* \end{pmatrix} \quad (1)$$

where the asterisk denotes conjugate complex. The transducer gain G_t at resonance is given by

$$G_t = 4 \frac{\omega_2}{\omega_s} \frac{R_a}{R_{ta}} \frac{R_\ell}{R_{t\ell}} \frac{\alpha}{(1-\alpha)^2} \quad (2)$$

where $\alpha = \omega_s\omega_2 L_1^2/R_{ta}R_{t\ell}$, and R_{ta} and $R_{t\ell}$, respectively, are total series resistances at ω_s and ω_2.

A typical result obtained by using signal frequency of 1 MHz and pumping frequency of 4 MHz is shown in Fig.3, where S/N performance of both the active and passive antennas are shown for the sake of comparison. It shows that about 6 dB sensitivity has been obtained. The passive antenna in this case has been matched to the input impedance of 50 ohms of the receiver. The theoretical calculations have been found in good agreement with experimental results.

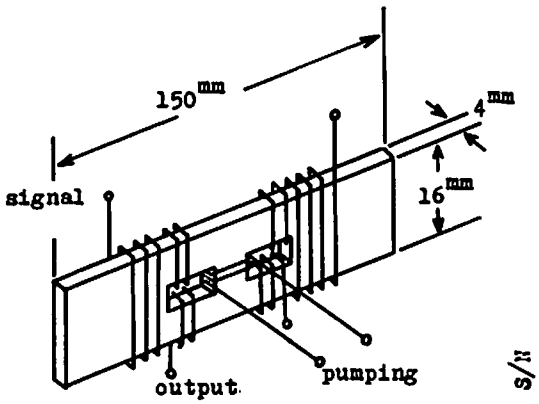

Fig.1. An experimental model.

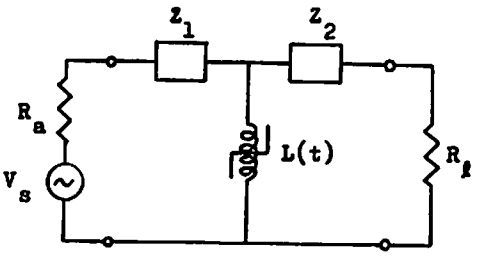

Fig.2. An equivalent circuit of the antenna shown in Fig.1.

3. Conclusion

The application of integration technique to ferrite antennas has been found to be quite successful. Although still many problems should be solved, this study suggests that sensitivity of ferrite antennas can be increased considerably by means of the integration technique, so far as the stability conditions are satisfied. In turn, an extremely small antenna having fairly high sensitivity, may possibly be realized in practice.

Reference

(1) L.A.Blackwell and K.L.Kotzebue, "Semiconductor-Diode Parametric Amplifiers", 1961.

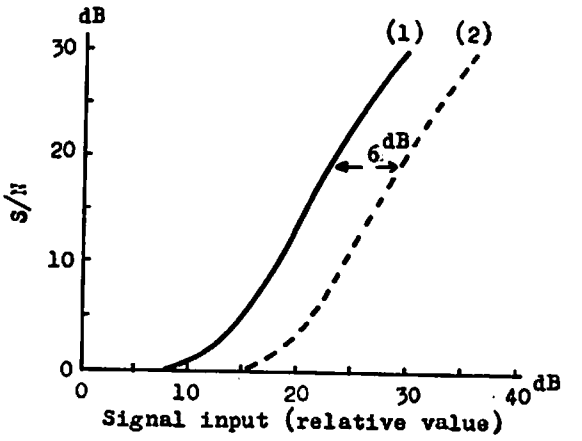

Fig.3. A typical S/N performance
(1) Active ferrite antenna (ω_s= 1 MHz, ω_p= 4 MHz, ω_2= 3MHz)
(2) Conventional ferrite antenna with same size as that of the active antenna and matched to 50 ohms (ω_s= 1 MHz)