1-II B2

RECEIVING PATTERNS OF A TRANSISTOR-LOADED-ACTIVE ANTENNA

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An asymmetrically fed dipole antenna, loaded with a transistor is studied theoretically and experimentally for the purpose of pattern control application. Essentials of the transistor integrated antenna system lie in modification or variation of current distributions on dipole elements. In practice, current distributions on dipole elements are varied by varying the parameters of transistor circuitry which is integrated into the antenna system, thereby attaining the antenna pattern flexibly: e, g., setting peak or null point of the pattern toward the desired direction. Also scanning may be possible by the similar approach.

Fig. 1 shows schematically a model studied. The antenna can be decomposed into unbalance and balance components as shown in Fig. 2, based on the mode of the antenna currents. Since the transistor has directional property, here the antenna is treated as only a receiving system[1].

(a) The unbalance component

The unbalance component is equivalently expressed by a linear antenna having two unequal potentials V_{1a} and V_{2a} on the element as shown in Fig. 2. The antenna is treated as a receiving system and the antenna current is obtained by solving the following equation;

$$\frac{1}{4\pi j\omega\varepsilon}\left(\frac{\partial^2}{\partial z^2}+k^2\right)\int_{-h_2}^{h_2}\frac{I(z')e^{-jkr}}{r}\cdot dz'$$
$$=V_{1a}(z-h_1)+V_{2a}(z+h_1)+E_0\sin\theta\, e^{jkz\cos\theta} \qquad (1)$$
$$r=\sqrt{a^2+(z-z')^2}$$

here the two potentials are expressed by delta-function generator placed on the element and k is a propagation constant in free space. The current which flows at terminals of a-b and d-f, respectively, are found as follows;

$$I(-h_1)=I_{1a}$$
$$=y_{11}(-h_1)V_{1a}+y_{12}(-h_1)V_{2a}+y_{1a}(-h_1,\theta)\frac{E_0}{k} \qquad (2)$$
$$I(+h_1)=I_{2a}$$
$$=y_{21}(+h_1)V_{1a}+y_{22}(+h_1)V_{2a}+y_{2a}(+h_1,\theta)\frac{E_0}{k} \qquad (3)$$

where
$$-V_{1a}\cdot Y_t=I_{1a}+I_{1b}=I_{L1} \qquad (4)$$
$$-V_{2a}\cdot Y_L=I_{2a}+I_{2b}=I_{L2}. \qquad (5)$$

Yt is the admittance looking into the transistor circuit at the terminal a-b, in Fig. 2. In these expressions,

$$y_{1a}=\frac{jP+Q}{30\sin\theta} \qquad (6)$$
$$y_{2a}=\frac{jP-Q}{30\sin\theta}, \qquad (7)$$

where the first order approximation of P and Q are given by,

$$P=\frac{\cos(qh_1)}{\Omega}-\frac{\cos(qh_2)\cos(kh_1)+\beta_{1e}}{\Omega\cos(kh_2)+\alpha_{1e}} \qquad (8)$$

$$Q=\frac{\sin(qh_1)}{\Omega}-\frac{\sin(qh_2)\sin(kh_1)+\beta_{1o}}{\Omega\sin(kh_2)+\alpha_{1o}} \qquad (9)$$

here $q=k\cos\theta$.

In the above expressions, α_{1e}, α_{1o}, β_{1e} and β_{1o} are the function of h_1 and h_2.

(b) The balance component

By the conventional transmission line theory,

$$V_{1b} = V_{2b}\cos(2\beta h_1) + jI_{2b}Z_o\sin(2\beta h_1) \quad (10)$$

$$I_{1b} = I_{2b}\cos(2\beta h_1) + jV_{2b}Y_o\sin(2\beta h_1) \quad (11)$$

where β and Zo(=1/Yo) are the propagation constant and the characteristic impedance of equivalent transmission line, respectively.

(c) The transistor circuit

With regard to the transistor circuitry, following relations are given by using Y- parameters in connection with antenna currents,

$$I_{1a} = Y_{11}(-V_{1a}+V_{1b}) + Y_{12}V_{1b} \quad (12)$$

$$-I_{1a}-I_{1b} = Y_{21}(-V_{1a}+V_{1b}) + Y_{22}V_{1b} \quad (13)$$

Other notations used are found in Fig. 1 and 2. It should be noted that transistor parameters are involved in both unbalance and balance components. The current I_{L2} which flows into the load Y_L is obtained by combining(2) to (13) as functions of the antenna dimension, transistor parameters and the incident electric field. In this case, the function of a transistor circuitry is to modify the amplitude and phase of the antenna current. The design of this antenna is made in such a way that the receiving pattern is deflected according to the variation of transistor bias voltage(V_B).

A typical result obtained by measurements and calculations, is shown in Fig. 3, where continuous deflection of the pattern with respect to the variation of V_B is shown. In the calculation, zero-order current approximation is used. Futher deflection is obtained by increasing the length of dipole elements; however, appreciable growth of side lobe is found.

In conclusion, it is confirmed experimentally and theoretically that the receiving patterns of a transistor-loaded-active antenna can be controlled by varying the parameters of the transistor circuitry. This may be applied to the pattern control and the scanning applications.

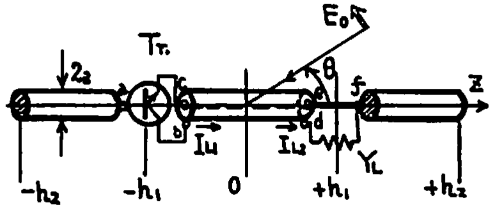
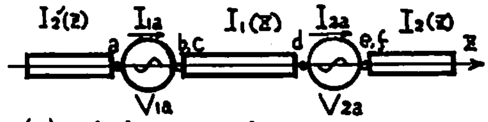
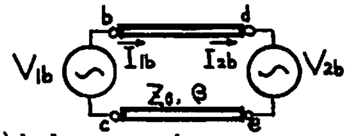


Fig. 1 Schematic Structure

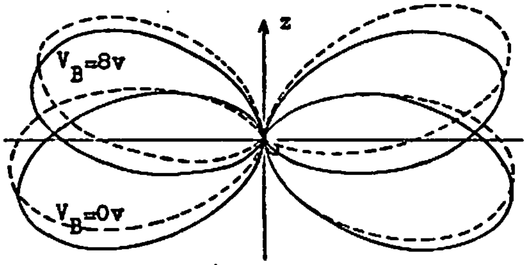


(a) unbalance mode



(b) balance mode

Fig. 2 Equivalent Expression



—— (calculation)

----- (experiment)

h_1=1/8λ, h_2=3/8λ, 2a=4 mmø

Freq. =868 MHz, Y_L=20m℧

Transistor; 2SC568

Fig. 3 Receiving Patterns

(1) K. Fujimoto, "A Treatment of the Integrated Antenna Systems." IEEE G-AP, International Symposium Digest, p.120, Sep. 1970, Ohio, U.S.A.