1-11 B3

UNIDIRECTIONAL ACTIVE ANTENNA

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Introduction

A dipole antenna is small in size however, its directional pattern is omnidirectional in its H-plane. Therefore, if a dipole antenna is used for TV reception, it recieves unwanted signals or noise and consequently the quality of picture decreases. In this paper we describe about a new active antenna which overcomes this fault, by means of inserting transistors into dipoles.

Principle

As indicated in Fig.1 two closely spaced dipole antennas are connected with each other by two transistors at their recieving terminals.

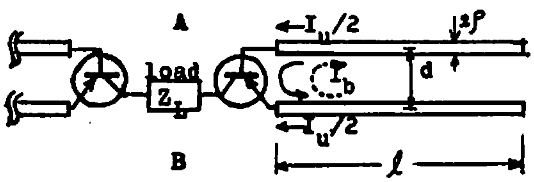

Fig.1 Configuration

When two transistors are connected as the figure, each small balance current I_b which flows circularly on two dipoles is amplified by each transistor, and these amplified currents flow in the load. At the same time, unbalance current I_u flows in the load. While the phase of I_u is independent from the direction of incident wave, the phase of I_b (solid arrow) which flows when wave comes from A direction is opposite to the phase (dotted arrow) when wave comes from B direction. Because of these difference, this antenna can become omnidirectional.

Analysis

This antenna can be analyzed by decomposing terminal voltages and currents into orthogonal sequencies as shown in Fig.2. From Fig.2, two equivalent circuits are introduced as indicated in Fig.3. In the figure, Z_u or Z_b is radiation impedance of unbalance or balance mode , and V_{0u} or V_{0b} is open circuit voltage of unbalance or balance mode induced by incident wave, + or - depends on the direction of incident wave.

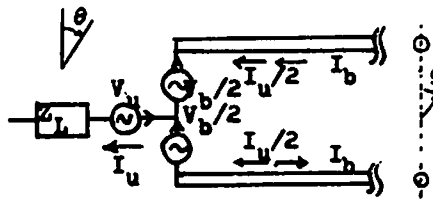

Fig.2 Decomposition

Common emitter transistor circuit is expressed in the form of Y-matrix. Then, from Fig.2 and 3 the relation between I_u, I_b, V_u, V_b, V_{0u} and V_{0b} can be written as Eq.1 using Y-matrix.

$$\begin{pmatrix} 0.5 & 1 & -y_{12} & 0.5y_{12}-y_{11} \\ -1 & 0 & y_{22} & y_{21}-0.5y_{22} \\ 0 & Z_b & 0 & 1 \\ Z_u+Z_L & 0 & 0 & 0 \end{pmatrix} \begin{pmatrix} I_{u\pm} \\ I_b \\ V_u \\ V_b \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ \pm V_{0b} \\ V_{0u} \end{pmatrix} \quad \cdots(1)$$

Eq.1 is a fundumental equation of this antenna.

Front to Back Ratio(F/B), Output Impedance, Output Voltage and Directional Pattern

F/B is determined by the following equation.

$$F/B = |I_{u+} / I_{u-}| \quad \cdots(2)$$

From Eq.1 and 2 F/B can be introduced independently from Z_u and Z_L.

Output impedance Z_{out} of this antenna is obtained by changing Z_u+Z_L in Eq.1 to Z_u, V_{0u} to V_0 and V_{0b} to 0. By this modification,

$$Z_{out} = V_0 / I_u \quad \cdots(3)$$

is obtained.

Output voltage V_{out} is expressed as follow.

$$V_{out} = \lim_{Z_L \to \infty} I_u Z_L \qquad \cdots(4)$$

From Eq.1 and 4,

$$V_{out} = V_{0u} + \frac{2V_{0b}(y_{21} - 0.5\,y_{22})}{y_{22} - Z_b(y_{12}y_{21} - y_{11}y_{22})} \qquad \cdots(5)$$

Using (2),(3) and (5), F/B, Z_{out}, and V_{out} can be calculated, when d, ρ, ℓ and (Y) have been determined previously. V_{0u} and V_{0b} in Eq.1 are as follows.

$$V_{0u} = 2\cos(kd/2)Eh \qquad \cdots(6)$$

$$V_{0b} = 2j\sin(kd/2)Eh \qquad \cdots(7)$$

where E is incident field
h is effective height.

Directional pattern is easily obtained when F/B is 0 or infinity.

$$D(\theta) = \frac{1+\cos\theta}{2} \cdot \frac{\cos(k\ell\sin\theta) - \cos k\ell}{\cos\theta\,(1-\cos k\ell)} \qquad \cdots(8)$$

$$D(\varphi) = (1+\cos\varphi)/2 \qquad \cdots(9)$$

θ and φ are indicated in Fig.2.

<u>Tolerance of Y-parameters</u>

From Eq.1, it is compreheded that an arbitraray F/B is obtained at an arbitrary frequency by selecting Y-parameters. The detail about this method cannot be mentioned due to the limitation of space, but the final results of y_{11} or y_{22} can be expressed as follows.

$$y_{11} \text{ or } y_{22} = C + M$$

C : constant
M : constant determined by F/B.

It is obvious that these results also stand for the tolerances of Y-parameters. And they mean that changing Y-parameter by switching can make this antenna wide band.

<u>Calculation</u>

In Fig.4-5 the results of calculation are shown. On this calculation, y_{22} parameter of transistor is changed by inserting additional admittance to make F/B infinity. The values d=5cm, ρ=0.5cm and ℓ=75cm are not large comparing to a conventional dipole antenna at about 100MHz. Transistors are 2SC-391 (manufactured by Toshiba). Z_{out} and V_{out} are omitted from this paper also due to the limitation of space.

<u>Experimental Results</u>

Some experimental results are shown in Fig.4-5.

Directional pattern is well coincident to theoretical pattern.

Additional admittance is inserted between emitter and collector.

F/B is somewhat different from the theoretical result, because of the difference of Y-parameters.

<u>Conclusion</u>

A new small active antenna which two transistors are inserted is analyzed and the theoretical results are compared with the experimental results.

About F/B, good result (more than 30 dB) is obtained.

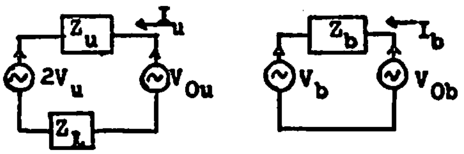

Fig.3 Equivalent circuits

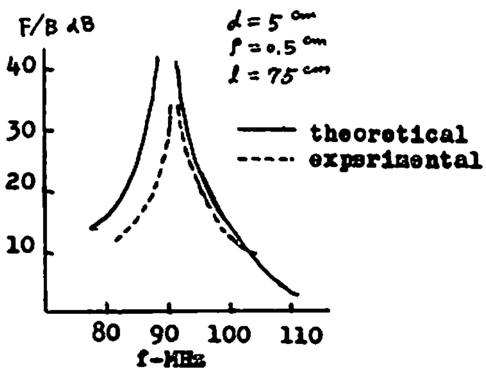

Fig.4 Frequency characteristics of F/B

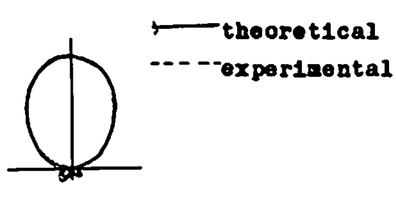

Fig.5 E-plane directional pattern