A MEANDER MODIFIED SELF-COMPLEMENTARY ANTENNA

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The property of self-complementary structures as frequency independent antennas is based on the Booker's relation (1). This property was pointed out by Uda and Mushiake (2) and was later extended to the formation of many new antennas (3,4,5). In two-port, three-dimensional complementary antennas the second port is terminated by a load impedance, Z_l , equal to the characteristic impedance Z_c of the antenna. These antennas however have reduced directivity due to the presence of several main lobes caused by the structure symmetry and finite size of the antenna planes. A modified self-complementary structure with improved directional properties is introduced by Ishizone et al. (6), which consists of only half of a complementary structure.

In this work a modified two-port three-dimensional structure with a meander strip is presented. Such a geometry is shown in Fig. 1. The monopole meander strip itself has the property of reduced resonant length when compared with a conventional monopole. The size reduction is typically about 40 percent (7). In the self-complementary antenna made of this strip, the load impedance, $Z_l = Z_c$ is connected between "c" and "d" with "a" and "b" as the excitation terminals. The feeding system consists of a thin coaxial cable with outer conductor grounded on the back of the plane and the inner conductor connected to the meander strip at "a" through a small notch at the edge of the slot. The aluminum ground plane has a dimension of 91.5 cm x 91.5 cm. The characteristic impedance Z_c , and the efficiency of this modified self-complementary antenna can be calculated by considering the equivalent network for these antennas suggested by Tai. Using the decomposition method (8) and constructing symmetrical and anti-symmetrical components in a two-port symmetrical network such that:

$$V_1 = V_a + V_b \quad , \quad I_1 = I_a + I_b$$

$$V_2 = V_a - V_b \quad , \quad I_2 = I_a - I_b$$

one finds, $Z_{11} = \frac{1}{2}(Z_a + Z_b)$ and $Z_{12} = \frac{1}{2}(Z_a - Z_b)$ where $Z_a = V_a / I_a$ is the symmetrical impedance and $Z_b = V_b / I_b$ is the anti-symmetrical impedance. The equivalent circuit for the original network based on these equations is shown in Fig. 2. If Z_a and Z_b are Considered to be linearly proportional to the input impedance Z_d and Z_s of an arbitrary strip and its complementary slot respectively, such that $Z_a = mZ_d$ and $Z_b = nZ_s$, according to Booker's relation, we will obtain $Z_a Z_b = mn/4 \ (Z_0)^2$ where , $Z_0 \simeq 377$ ohms. If a load impedance $Z_l = \frac{1}{2}\sqrt{mn}\ Z_0$ is selected, from the equivalent network. it can be verified that the input impedance is equal to

$$Z_{in} = \tfrac{1}{2}\sqrt{mn}\ Z_0$$

which is equal to the charactristic impedance Z_c of the antenna.

For the modified self-complementary antenna with the meander strip we will have a value of m=1 and n=½ and therefore $Z_C \simeq 133$ ohms. Since the 6mm height load (a ceramic cylinder covered by a resistive paint) is not sufficiently small in height. the distance of the meander strip from the plane is more than necessary and this results in the lack of an accurate complementary structure creating some impedance changes over a wide frequency range. In addition, the nature of the load itself deviates from a pure 133 ohm resistor and exhibits a reactive part as the frequency is increased. The impedance of the antenna is shown in Fig. 3 Over a 10:1 bandwidth (0.11 to 1.1 GHz). The locus of a short circuit is also shown on the chart as a reference over the same frequency band. It is seen that the impedance starts from a value of Z_{in} = 133 ohms and remains relatively constant in the lower portion of the band. As the frequency increases, a reactive component appears shifting the impedance from its initial value on the chart.

Since the meander strip shows a resonant resistance of 9.5 ohms. i.e., Z_a =19 ohms. the efficiency of the self-complementary antenna with this meander strip , using its equivalent network is found to be only 44 percent. A modified self-complementary antenna with a monopole strip (6 , 9) has a better efficiency due to its higher resonant resistance. To improve the efficiency of the modified self-complementary antennas. one can think of increasing Z_a up to the value of Z_C , but this is equivalent to an increase of the input impedance of the strip by changing its shape in return for less size reduction.

Generally speaking, the complementary structures. while having good impedance properties. have the disadvantage of low efficiency and the necessity of providing a large plane. In addition the pattern of these antennas are disturbed by the finite size of the ground plane. The modified self-complementary structure with the meander strip introduces a size reduction resulting in a compactness of about 40 percent.

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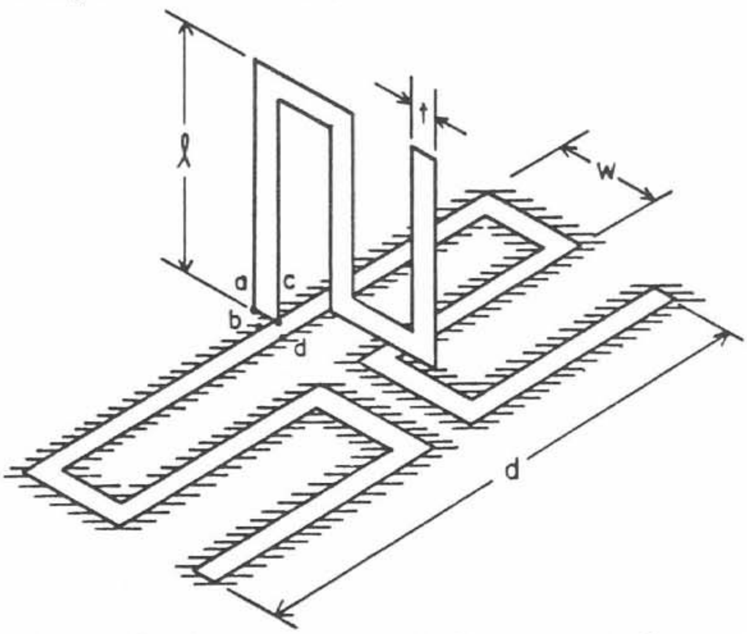

Fig.1: Geometry of the antenna, W=7 mm, t=1.5 mm,d=3cm & l≃14mm.

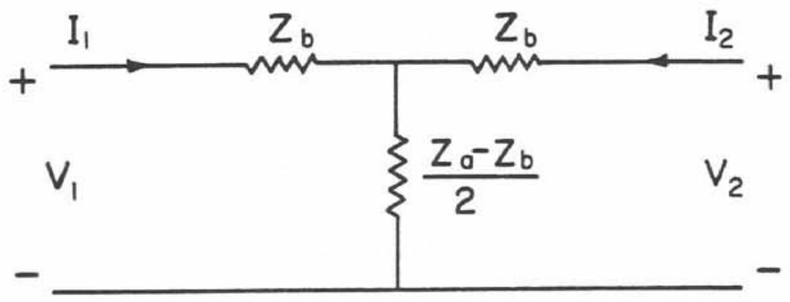

Fig. 2: The equivalent network for a two-port symmetrical structure.

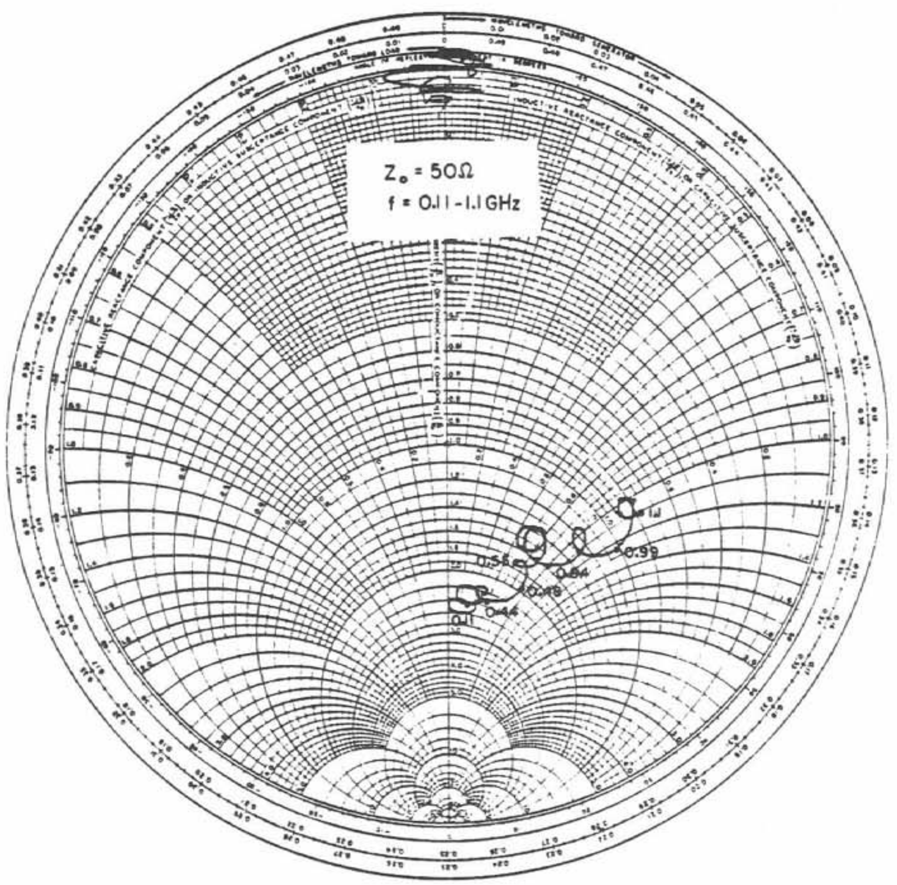

Fig. 3: Impedance of the antenna over a 10:1 bandwidth.