the superconductor and the skin depth, the surface impedance is complex and is given by

\[ Z = \left[ \frac{\mu_0}{2\pi} (\sigma_1 - j\sigma_2) \right]^{-1} \] (3)

On the other hand, for the superconducting ground plane [Figure 1(c)] we consider a layer with a complex conductivity \((\sigma_1 - j\sigma_2)\).

**NUMERICAL RESULTS**

When a superconducting strip is taken into account, the use of the complex boundary condition is an approximation in electromagnetic theory; so such modelization must be tested, particularly when narrow strips are considered. In this mind, for a classical metallic gold strip structure, we have compared the modified SDA results with finite element ones [5]. Figure 3 exhibits that the modelization of the boundary condition of the conductive strip by the surface impedance gives results more rigorous than finite element analysis, including the 10 \(\mu \text{m}\) wide strip.

After that verification, we can present the evolution of the attenuation and of the slow wave factor versus the reduced temperature \(T/T_c\) for the two kinds of superconductors, exhibiting different behaviors of \(\sigma_1\) and \(\sigma_2\). Figure 4 shows these evolutions for several sets of geometrical cross sectional microstrip lines. Two kinds of structures have been simulated, one with a perfect metallic ground plane and the other one with a superconducting ground plane. Naturally, the physical propagation phenomena associated with that kind of transmission line are known. In fact, a lot of works have explained the reasons for the propagated slow wave mode. But our aim is to quantify more exactly, in an engineering purpose, these propagation phenomena in order to take into account the real nature of the hybrid mode and the real geometry of propagation structure. The observation of the curves exhibits that, for a usual superconductor (low critical temperature), we naturally obtain for a small superconducting strip with a perfect ground plane, the highest slow wave factor and the lowest attenuation while a superconducting ground plane reduces the slow wave factor.

For the superconductor with high critical temperature, at the vicinity of the critical temperature, the presence of a superconducting ground plane makes the value of the slow wave factor sensitive for small variation near the high \(T_c\) critical temperature. We can note also that without the superconducting ground plane, the slow wave factor falls down in the vicinity of the high \(T_c\) critical temperature [Figure 4(a)].

**CONCLUSION**

We have shown in this communication the influence of a superconducting strip and ground plane for two kinds of superconductors on the propagation characteristics, one with low critical temperature and the other one with high \(T_c\) critical temperature. Naturally, the validity of these results is conditioned by the simplified modelization of the superconductors that we used and the preceding results are subject to the usual restrictions of the application of the surface impedance boundary condition. Meanwhile, the different behavior obtained for these two superconductors exhibits the necessity to get more experimental data on the high \(T_c\) superconductor in the microwave frequency range, because the high value of the critical temperature does not systematically give the desired evolutions of \(\sigma_1\) and \(\sigma_2\) versus the reduced temperature in order to obtain low losses and a high slow wave factor in the microwave frequency range.

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**BROAD-BAND REACTIVELY LOADED DIPOLE ANTENNA**

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**KEY TERMS**

Dipole antenna, moment method, broadband techniques

**ABSTRACT**

A dipole antenna is an inherently frequency-sensitive device. The frequency characteristics of the dipole are governed by the current that is induced along the radiating element. Herein, we suggest a design technique of reactive loading, aiming to maintain the current distribution, and consequently the input impedance and the radiation pattern, nearly constant over a wide band of frequencies. The promising potential of the loading scheme is demonstrated via a moment-method numerical simulation that shows that even with a single optimal lumped reactive load a notable 5 : 1 bandwidth with VSWR < 5 is attainable.

**I. INTRODUCTION**

Modern communication systems that use dipole antennas are required to respond faster to frequency hopping while simultaneously keeping an even as well as effective performance over a wide range of frequencies. Since the dipole is an inherently highly frequency-sensitive device, coupling-matching networks have been designed to match the antenna terminals to the feeding structures. The classical technique, which uses a number of either mechanically or electronically switched narrow-band coupling-matching networks to cover the wide frequency band, renders the antenna response extremely slow.

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