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평행평판 도파관의 윗면에 위치한 좁은 슬릿과 넓은 슬릿을 통한 도체 스트립에로의 전자기적 결합

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Electromagnetic coupling to nearby conducting strip through narrow and wide slits in parallel plate waveguide.

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ABSTRACT

평행평판의 윗면에 위치한 슬릿을 통하여, 슬릿의 바로 윗 부분에 도체 스트립이 있을 때 일어나는 전자기적 결합 현상에 대하여 살펴보았다. 슬릿의 폭이 파장에 비하여 매우 작을 때와 매우 클 때의 두 경우로 나누어서 기술하였다. 슬릿의 폭이 좁은 경우는 기존의 개구결합(aperture-coupled) 마이크로스트립 안테나에 해당되며 슬릿의 폭이 넓은 경우는 기존의 proximity-coupled 마이크로스트립 안테나에 해당된다. 본 연구의 결과는 기존의 마이크로스트립 안테나의 급전구조와 기존의 마이크로스트립 누설파 안테나의 급전구조 설계에 도움을 줄 것으로 생각된다.

The problem of electromagnetic coupling to a conducting strip through narrow and wide slits in a parallel-plate waveguide (PPW) is considered for the purpose of understanding more about the coupling mechanisms of aperture-coupled and proximity-coupled microstrip antennas. The problem for consideration· is "Under what conditions can most of the incident power P_{inc} be radiated into the upper-half free space", i.e., can perfect matching occur?"

The first geometry under consideration is given in Fig. 1, where z_s is the short stub length from the narrow slit center, the TEM field is assumed

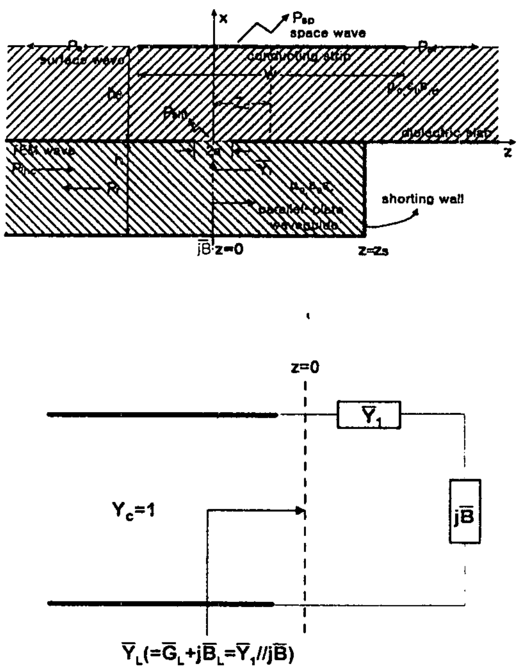

Fig. 1. Geometry for narrow slit problem and its equivalent circuit representation

to be incident upon the slitted region, and the height h and inside dielectric constant $\varepsilon_0 \varepsilon_r$ of PPW are chosen to be comparable to those of a typical microstrip structure.

A pair of coupled integral equations is formulated whose unknowns are the induced electric current density on the conducting strip and the equivalent magnetic current density over the shorted slit and which is solved using the Method of Moment(MoM).

For a narrow slit case, where the slit width $2a$ is much smaller than the wavelength λ in the PPW and the PPW height h, similar to a typical aperture-coupled microstrip antenna, almost perfect matching can be achieved by introducing the short stub scheme, as shown in Fig. 1. The location Z_S of the shorting wall in the PPW is chosen to be about $\lambda/2$ away from the slit center such that the length Z_S of the short stub plays the same role as that of the quarter wavelength open stub of the microstrip line used in typical aperture-coupled microstrip antennas. Two types of coupling mechanisms can facilitate such perfect matching, cavity-type and parasitic-type. Cavity -type coupling uses a smaller separation h_d than the parasitic-type, as such, a strong mode field (TM_{01} mode to x- direction) is excited in the cavity between the strip and the upper plate of the PPW. so the magnitude of the induced electric current density on the strip is much larger than that for the parasitic-type. Because of the half cycle variation of the TM_{01} mode(x- component electric field) along the z-direction, the strip offset Z_C which produces the perfect matching is then observed at two offset positions symmetrical about the zero offset position.

In contrast, the parasitic-type coupling uses a relatively larger separation h_d , therefore, a strong mode field is not excited. However, the radiation beam is more directive than that for the cavity-type, and maximum coupling occurs when the offset Z_C is zero. In this sense, the strip behaves more as the driver of the 2-element Yagi-Uda array instead of forming a cavity along with the upper plate of the PPW. Although the two types are quite different from each other, as described above, the roles of the strip are the same in both types. That is, at perfect matching, the presence of the strip increases the very small load conductance from the value the load admittance $\overline{Y_L}$ would have without the presence

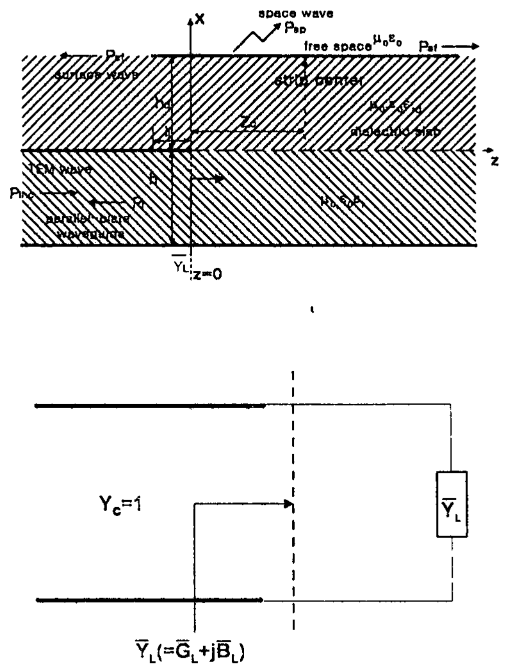

Fig. 2. Geometry for wide slit problem and its equivalent circuit representation

of a strip to almost the same value as the characteristic admittance of the PPW. Furthermore, the strip also provides the required inductive susceptance for resonance with a large capacitive susceptance, which the load admittance would have without the presence of a strip. This also occurs in the case of a wide slit.

In the case of a wide slit where the location Z_S of the shorting wall is moved to positive infinity, i.e., $Z_S \rightarrow \infty$ and the slit width 2a becomes comparable to or larger than the wavelength λ in the PPW, the power transmitted to the guide beyond the slit becomes negligible, therefore, the problem in the wide slit case can be reduced to the structure as shown in Fig. 2. This second geometry under consideration can be thought of as a simplified structure of a proximity -coupled microstrip antenna. Similarly, in the case of a wide slit, there are also two types of radiative coupling, cavity-type and parasitic-type. In the case of cavity-type coupling, when the offset position Z_C is ,for example, -0.18 λ_d,(here λ_d : wavelength in dielectric slab), maximum coupling (perfect matching) is achieved when h_d is so small that a cavity can be formed between the strip and the upper plate of the PPW. In contrast, in parasitic -type coupling, as the relative dielectric constant ε_{rd} of the dielectric slab is decreased and it's thickness h_d is increased gradually, the offset position which produces the maximum coupling is moved to the point where $Z_C = 0$. As in the case of a narrow slit, the induced current distribution on the strip with cavity-type coupling is signifi- cantly larger than that for the parasitic -type. In addition, perfect matching can also be achieved when $h_d + h$ in Fig. 2 is so small that a cavity can be formed between the strip and the lower(ground) plate of the PPW, plus the inserted length l_i of the upper plate of the PPW is so small that the inserted part does not result in any significant perturbation to the cavity.

It is believed that the above observations will help in designing various feeding structures for aperture -coupled and proximity-coupled antennas as well as microstrip leaky wave antennas.

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