RESONANT FEEDING NETWORKS FOR MICROSTRIP ANTENNAS

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Abstract

A novel technique for feeding microstrip antennas is proposed. The feeding network, made of microstrip lines, is designed to propagate standing waves, instead of traveling waves as usually is done. At its resonance, the incident and reflected signals combine with each other, and results in a stable and periodic field distribution along this network. Thus, coupled patches can be excited with equal magnitude, and either equal phase or phase opposition, depending on the desired radiation pattern. They also bring an additional resonance, which, added to that of the patch enhances the input impedance bandwidth. Also, no power dividers or matching stubs are necessary, leading to constructional simplicity. Three examples of resonant feeding networks are presented (Fig.1), which provide three different resonating modes.

I. The halfwave resonating dipole

The first presented feeding network consists of a halfwave resonating dipole. At the resonance, it exhibits a symmetric current distribution with respect to its center. Let us couple electromagnetically two radiating patches, as displayed in Fig.1a. The open circuited loads of the radiating edges of the feeding dipole are therefore changed into loads equal to the input impedances of the patches. If their value is different from the characteristic impedance of the dipole, the resonance is still excited and the patches are fed in equal magnitude and phase. The resonance of the patch combines itself with that of the feeding dipole, and widen the bandwidth. The impedance plot on the Smith chart indicates a loop, whose size depends on the magnitude of the coupling between the line and the radiator [1]. Thus, a larger separation between the two radiating elements decreases the coupling (Fig.2), but increases the relative radiation of the feeding line compared to that of the patches, and may alter the radiation pattern of the antenna. An improved version of this configuration was realized by widening the line and coupling it to four patches symmetrically arranged on top of its four corners [2].

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II. The resonating cross

The second resonant feeding network is made of a symmetric microstrip cross, fed at its center, and made of four arms, or two branches, one longitudinal and the other transversal. The symmetry of the configuration insures that each branch supports the same current distribution. The length of each branch is approximately set to a guided wavelength, so that the second resonant mode TM_{02} is excited longitudinally and transversally. It gives a longer network than the previous one, and can excite four square patches, located on the tips of each arm. However, because the excited mode is an odd mode, the current flowing on two opposite arms are in phase opposition. Then, their resulting radiations cancels at broadside, but add at a constant elevation angle in all planes, Fig.3, which depends on the antenna parameters ($\varepsilon_{r_1} = \varepsilon_{r_2} = 2.55$, $H_1 = H_2 = 1.58$ mm, L = 24 mm, L_c = 48 mm, W_c = 6 mm, s = 42 mm). The relative radiation of the feeding network is approximately constant at about -20 dB, Fig.4, when the feed arms width is smaller than that of the patches. This configuration was also designed for circular polarization.

III. A larger feed network of resonant H

A third and novel configuration is proposed, which presents the advantage of feeding four patches with identical signals in a relatively large aperture. ($\varepsilon_{r_1} = \varepsilon_{r_2} = 2.55$, $H_1 = H_2 = 1.58$ mm, $L_1 = W_1 = 30$ mm, s_x = 36 mm, s_y = 48 mm, L_a = 9 mm, L_b = 24 mm, L_c = 30 mm, $W_a = W_b$ = 6 mm, W_a = 12 mm). It is composed of four arms connected to a common section fed by a probe source. Because of the geometry, the two arms located symmetrically in the H plane, deliver the same excitation signal to electromagnetically coupled patches. Then, each section length is adjusted, so that the total distance between the two opposite arms in the E plane equals approximately one wavelength and a half. Hence, a resonating TM_{30} mode may be excited in this feeding device, giving currents with equal magnitude and phase at its four extremities. The most sensitive parameter of this network is the ratio between the length of the arms and that of the common central section. The ratio of the line widths is also important, since it may be responsible for another resonance, which occurs in the central line, and is generated by the appearance of discontinuities at its junctions. This has to be avoided since it alters the radiation pattern. The impedance of the optimized configuration is wide band and low resistive, Fig.5, and can be changed by modifying the width of the lines. The feeding device radiates 20 dB less than the patches, and does not distort the radiation pattern. However, it presents high sidelobe levels in the E plane, Fig.6, since the field distribution is too weak at the center of the aperture, representing a central null. They can be reduced by increasing the permittivity of the lower substrate and therefore decreasing the size and the directivity of the array.

References

[1] H. Legay and L. Shafai, "Parametric analysis of an EMC patch surrounded by parasitic elements", submitted to publication to Proc. IEE.

[2] H. Legay and L. Shafai, "A new stacked microstrip antenna with large bandwidth and high gain", submitted to publication to Proc. IEE.

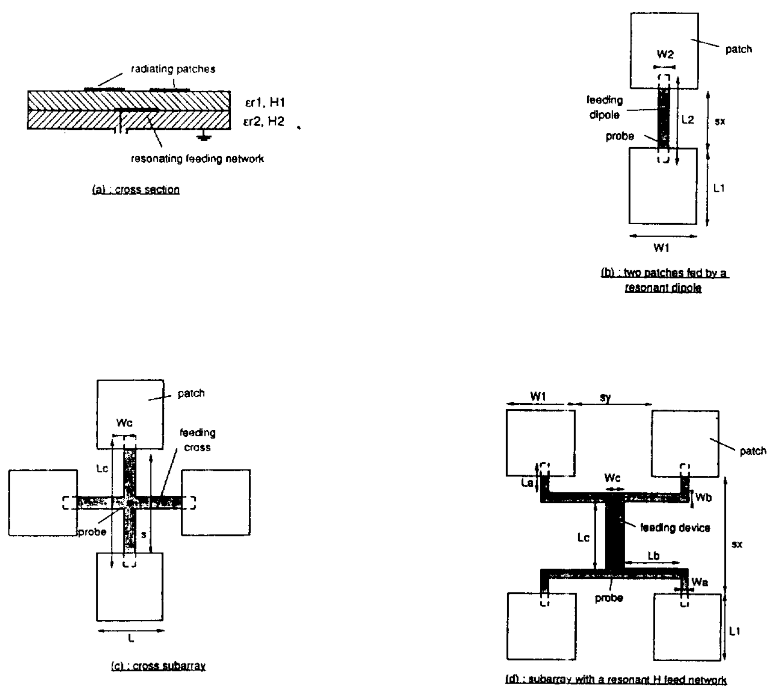
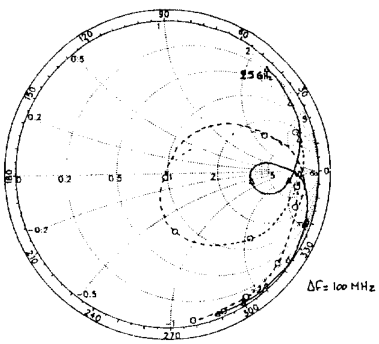


Fig.1 : Examples of subarrays using a resonant feeding network



(O : s = 26 mm, Δ : s = 30 mm).
$\varepsilon_{r_1} = \varepsilon_{r_2} = 2.55$, $H_1 = H_2 = 1.58$ mm
$L_1 = 30$ mm, $W_1 = 30$ mm
$L_2 = 30$ mm, $W_2 = 8$ mm

Fig.2 : Input impedance for different separations between the two upper patches.

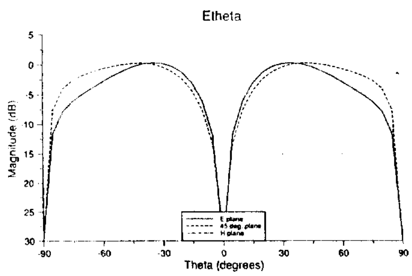


Fig.3 : Radiation Pattern of a cross subarray

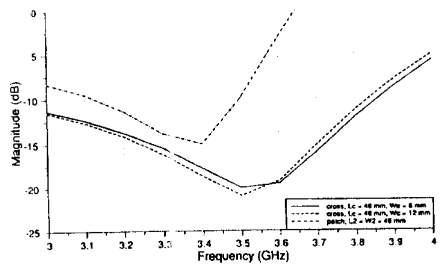


Fig.4 : Relative radiation of the feed network.

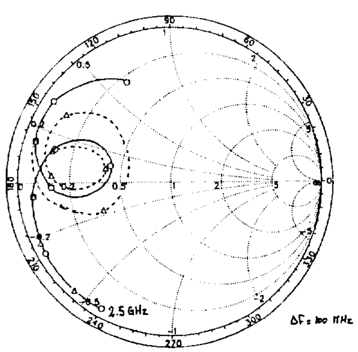


Fig.5 : Input impedance of a subarray with a resonant H feed network. (O : W_c = 12mm, Δ : W_c = 30 mm)

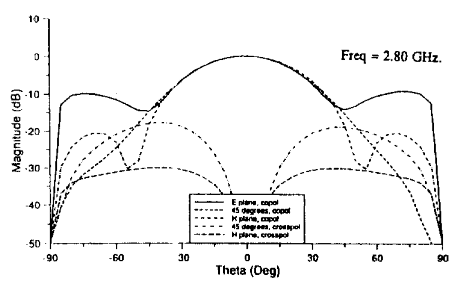


Fig.6 : Radiation pattern.

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