DOUBLE PATCH MICROSTRIP ANTENNA FOR BROADBAND APPLICATION

Ulrich MECK*, Hitoshi MIZUTAMARI**, Yuji KOBAYASHI**, Takashi KATAGI**

* MBB GmbH,Space Communications and Propulsion Systems Div.
Munich,Federal Republic of Germany
** Mitsubishi Electric Corporation, Kamakura Works, Kamakura, Kanagawa, Japan

1. Introduction

A specific characteristics of microstrip antennas is their narrow bandwidth which is usually only a few percent of the center frequency. It is known that the bandwidth can be improved by a double patch configuration[1], that is, one active patch and a passive one placed on top of the active patch. In this paper the numerical solutions of the impedance characteristics by moment method is introduced. The parametric study shows that bandwidth characteristics of the double patch antenna can be optimised by choosing the ratio of upper and lower patch length and passive patch height. Calculated results and measured results of the test model show good agreement.

2. Theory

The microstrip antennas under investigation are of rectangular shape, fed with coaxial probe. A configuration of two pararell stacked patches is shown in Figure 1[2]. The patches are embedded in a dielectric material with $\varepsilon_r > 1$.

To establish a system for the calculation of unknown patch current on the patch, the reaction principle is applied[3].

$$0 = \iiint_{Source} \vec{E}\ \vec{J}_{source}\, dx\, dy\, dz + \iint_{patch} \vec{E}_{tang} \vec{J}_{patch}\, dx\, dy \tag{1}$$

All field components and currents are transformed according to Fourier's rule for spectral presentation as follows:

$$\begin{aligned} 0 = &\sum_{zi} \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} [\int_{0}^{zi} \vec{E}(kx,ky,z)dz]\, \vec{J}_{source}(-kx,-ky)\ dkx\, dky \\ &+ \sum_{zj} \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} \vec{E}t(kx,ky,zj)\ \vec{J}_{patch}\ (-kx,-ky)\ dkx\, dky \end{aligned} \tag{2}$$

To evaluate complex integro-differential equations for electromagnetic equation (2), the moment method is an effective instrument and in the case of these microstrip antennas,the expansion modes and the test modes are chosen to be the same. (Galerkin's method.).

The entire basis modes are chosen for the patch currents[4]. For the unknown patch currents,

$$\vec{J}_{patch}(kx,ky) = \iint_{patch} \left(\sum_{n=1}^{Nx} \vec{x} I_{nx}\phi_{nx} + \sum_{n=1}^{Ny} \vec{y} I_{ny}\phi_{ny}\right) e^{-jkx x' -jky y'} dx' dy' \quad (3)$$

for the source currents with given amplitudes I_{sj}

$$\vec{J}_{source}(kx,ky) = \iint_{Source} \sum_{j=1}^{Ns} \vec{z} I_{sj} e^{-jkx x' -jky y'} dx' dy' \quad (4)$$

where Ns = Number of sources

I_{nx}, I_{ny} unknown amplitudes of the patch currents

ϕ_{nx}, ϕ_{ny} expansion modes

Applying the expansion of the unknown patch current and the testing of the field intensity for the reaction equation (2), unknown patch current amplitudes can be solved by the moment methods[5].

$$0 = U_m + \sum_{n=1}^{N} z_{mn} I_n, \quad m = 1, 2, \cdots, M (=N)$$

$$0 = (U) + (Z)(I) \quad (5)$$

(U) and (I) are vectors of dimension N,which is the sum of Nx unknown x-currents and Ny unknown y-currents. (Z) is a square matrix to give the coupling coefficients between expansion elements and testing elements of the equation system.

The input impedance is then obtained as

$$Z_{in} = -\sum_{n=1}^{N} I_n U_n \quad (6)$$

To get the input impedance at the ground plane, the inductivity of the feed pin of the coaxial probe has to be calculated by the formula[4],

$$X_L = 60 k_0 D \ln \frac{2}{k_0 d_0 \sqrt{\varepsilon r}} \quad (7)$$

where D=length of feed pin, d_0 =diameter of feed pin.

3. Results and Discussion

The calculation results of single patch antennas show good agreement with the test results and the results of other authers such as Bailey[4], Figure 2 shows the mesurement and calculation results of a single patch.

In this paper the characteristics of a double patch antenna with a dielectric composed by a NOMEX honeycomb material and cover sheets made of Kevlar as shown in Figure 3 are examined. The ratio of a passive patch length b to an active patch length a, b/a, and the ratio of passive patch height h to the resonant wavelength λ_o are the important parameteres of the double patch. Figure 4 shows the bandwidth characteristics of the double patch antenna for VSWR≦1.5 with the parameters b/a, and h/ λ_o. which are calculated using this analysis method. The broadband characteristics of the double patch antenna are sensitive both for b/a and h/λ_o. however it is clear that the characteristics larger than 5% of VSWR ≦1.5 are easily available over wide range of h/ λ_o. 0.07 to 0.1 by choosing a b/a. Figure 5 shows an example of the broadband impedance characteristics of the experimental model. The measured and calculated results show good agreement and the measured bandwidth of VSWR≦1.5 is about 8%.

4. Conclusion

A theory and a numerical method are presented to calculate rectangular patch antennas and double patch antennas taking into account the coupling between the patches. The parametric study for the broadband characteristics of the double patch antenna has been performed. The calculation results show good agreement with the measured results.

References

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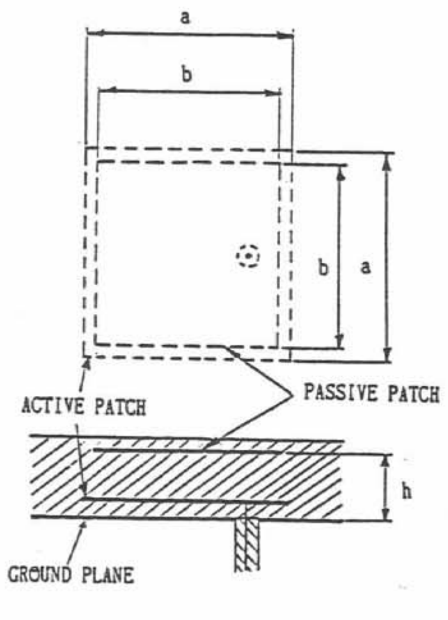

Figure 1 Double patch antenna.

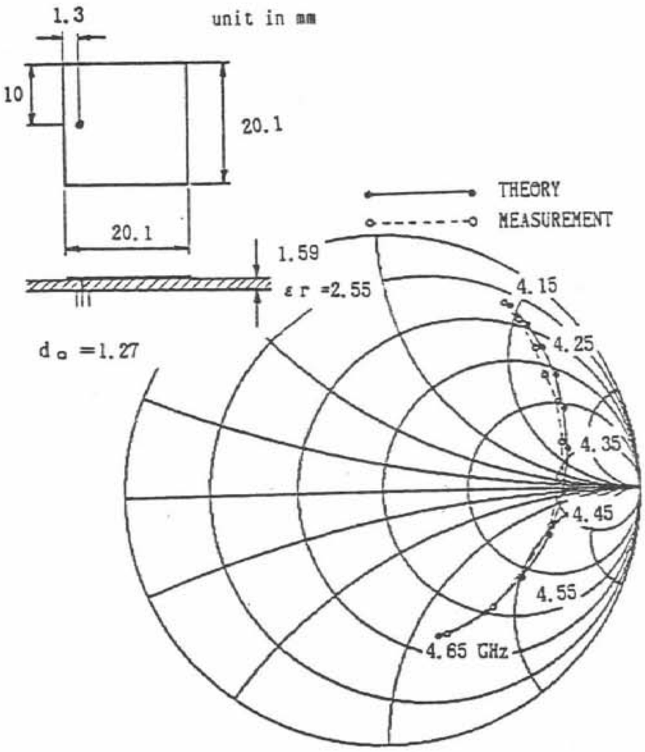

Figure 2 Input impedance of single patch antenna.

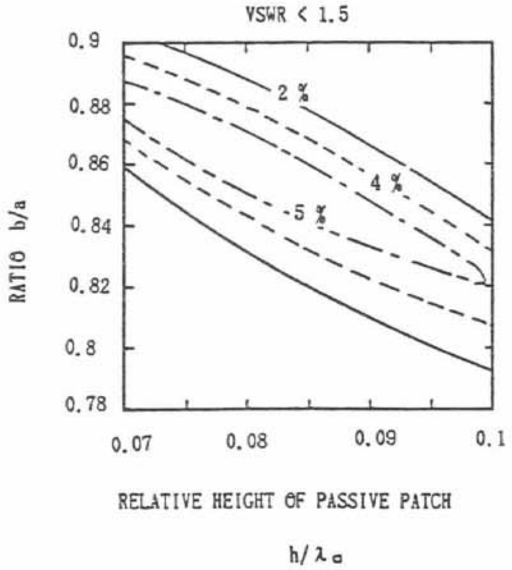

Figure 4 Relative bandwidth variation for passive patch height and length ratio of upper and lower patch. (VSWR<1.5)

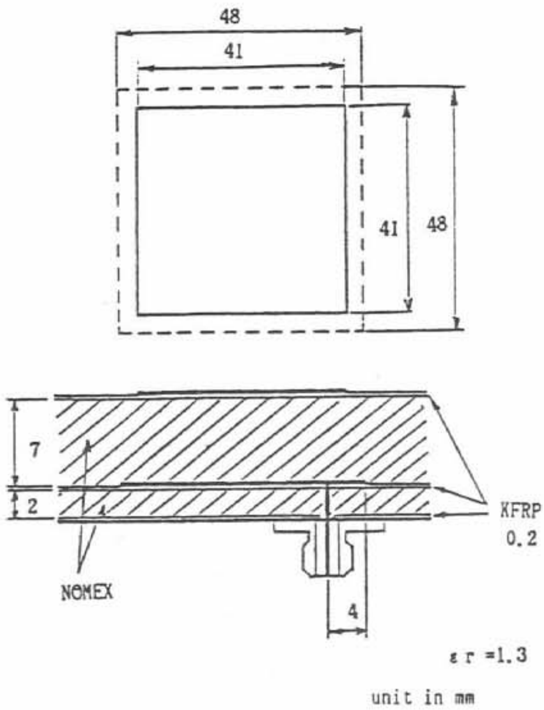

Figure 3 Double patch antenna.

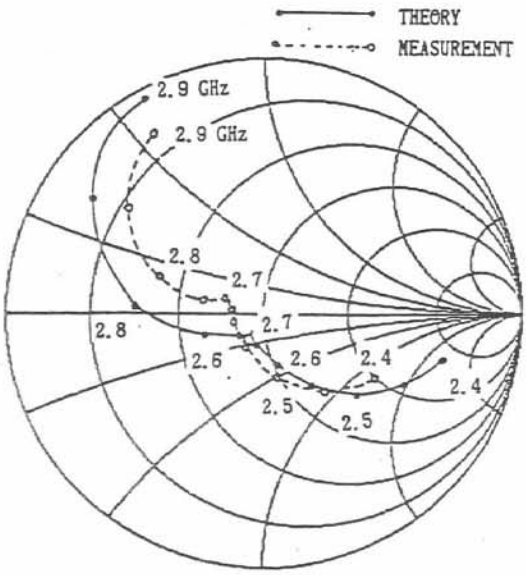

Figure 5 Input impedance of the double patch antenna.