Forum for Electromagnetic Research Methods and Application Technologies (FERMAT)

Antenna Design Using Characteristic Modes and Related Techniques.

Comments and Questions on the EuCAP presentation on, "On the interaction of Characteristic Modes in Slot Antennas etched on Finite Ground Planes, by N. Mohamed *et al.* in the EuCAP'16 Special Session on *Theory and Application of Characteristic Modes,* convened on Monday, April 11, 2016

The author began her presentation by analyzing a slot in a finite ground plane as shown in Fig.1 below.

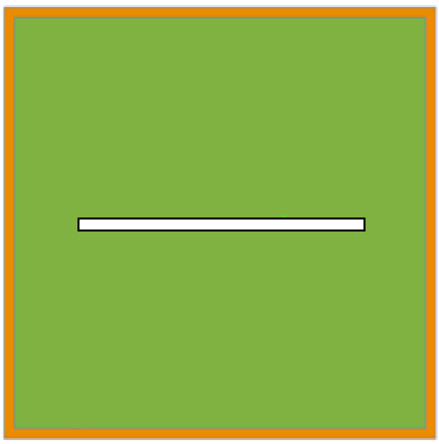

Fig.1. Slot in a finite ground plane

(Note: The slot shape was changed to U-shaped later in the presentation, and results were presented for both.)

Characterisitc modes (CMs) were derived for the slotted plane by using an eigenvalue equation formulated in terms of magnetic current M, as opposed to electric current J, which is appropriate for this geometry. "Resonance" was defined for the CMs by using the criterion that at resonance the Characteristic angle (CA) goes to 180^0. Different CMs "resonated" at different frequencies (except when the modes were degenerate).

This exercise was followed by an analysis of the same geometry when excited by a voltage source located at the center of the slot, as shown in Fig. 2 below

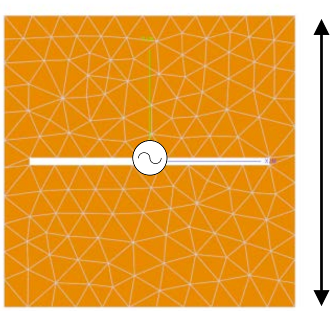

Fig.2. Slot in a finite ground plane excited by a source located at the center of the slot

The results for the input resistance and reactance were plotted as functions of frequency, as was the S_{11}, for the excited slot. It is very easy to find the resonance of the geometry from these plots, and it was around 7 GHz for the case studied. It is important to recognize that the excitation case provides the true resonance frequencies, at which the input reactance goes to 0, and the return loss hits a minimum. In contrast to this, the CM analysis works with an auxiliary eigenvalue equation

$$B\left(\vec{M}_n\right) = b_n G\left(\vec{M}_n\right)$$

where B and G are susceptance an conductance matrices (real an imaginary parts of the admittance matrix Y), respectively, M is the magnetic current, and the formulation is source-free. It has been pointed out by people knowledgeable in our field that the open structure can only have resonances at complex frequencies, since theoretically they (open structures) cannot have resonances at real frequencies, similar to those of closed cavities.

Anyway, if we are searching for resonances, the authors do not explain why don't we just look at the input reactance and the return loss characteristics to find them? Granted these resonances do depend on the excitation as well as the geometry of the structure, whereas the CMs are source-independent. But the authors never discuss the "launching" issue of the CMs, nor do they explain, or show, exactly what the CM analysis gains *over* the "excitation' case (which they also investigate), by deriving so many CMs which vary all over the map. They do not explain what they do with all this CM information by using a realistic case example for designing a slot antenna—a relatively straightforward problem, we think.

If we are designing a slot antenna on a finite ground plane, operating at a given frequency, we could simply excite the slot—typically but not necessarily at the center—and look for its return loss characteristics and patterns, as we vary the slot parameters, e.g., its length and/or its shape, as well as the location where it is excited, and learn all we need to in order to carry out the design. The authors have not convincingly demonstrated that they have a distinct edge over the legacy approach if they choose to go the CM route. It would be very helpful to antenna designers if they elaborate on this point and convincingly demonstrate, via the use of an example, that they are better able to do the design than when conventional approaches are used. It would also be helpful if the authors explain why they derive so many CM results, including their CA plots, in their presentation when discussing the slot antenna shown in Fig.2, *with the excitation in place*? After all, it is our understanding that the CMs are supposed to be excitation-independent, are they not? Then, what is the meaning of the CMs they presented for the excitation case and what do we do with them?

Submitted by: a novice in the area of CMs but very willing to learn