Forum for Electromagnetic Research Methods and Application Technologies (FERMAT)

Antenna Design Using Characteristic Modes and Related Techniques.

Comments and Questions on the presentation, "Bi-directional Pattern of Two-Notch Antenna by Characteristic Modes Analysis," by Arai et al. in* the EuCAP'16 Special Session on *Theory and Application of Characteristic Modes, convened on Monday, April 11, 2016

This paper is an interesting example of antenna design using the Theory of Characteristic Modes (TCM)

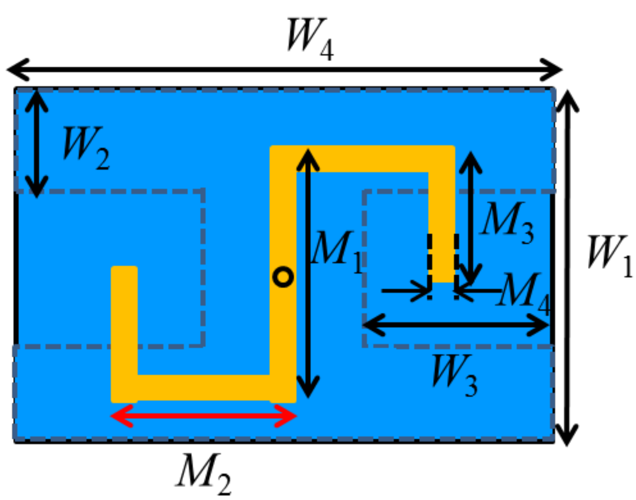
Excerpts from Arai *et al*, Abstract in EuCAP'16

"Theory of characteristics modes (TCM) provides antenna designers with physical insights based on eigenmode analysis, because it can accurately predict a structure's near- and far-field radiation behavior independent of the feeding arrangement."

"TCM also gives useful information on how to design the antenna feed to excite the desirable radiation modes, which provides a systematic approach to designing antennas that can take advantage of the whole design space to fulfill a given set of requirements."

"The bi-directional pattern is btained by isolating J2 mode with others for deep nulls. The patterns of this simple antenna are easily controlled by antenna geometry with the aid of TCM, which provides useful applications in small antennas."

Figure below shows the proposed antenna by Arai et al.



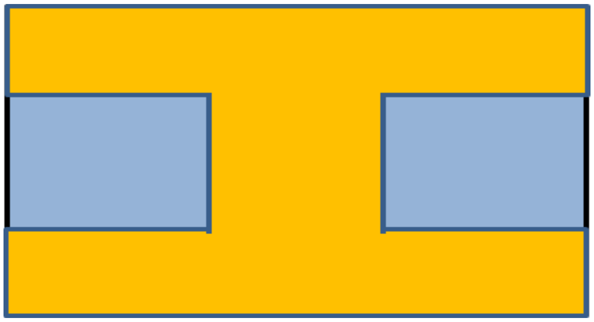


Fig.1. Geometry of Arai Antenna. Top view above and bottom (defected ground plane) view below.

The figure below is from the Arai *et al.* Abstract, showing the Characteristic Angles (as defined by Newman), or CAs, for three different modes. Dashed and solid lines correspond to two different choices of antenna parameters.

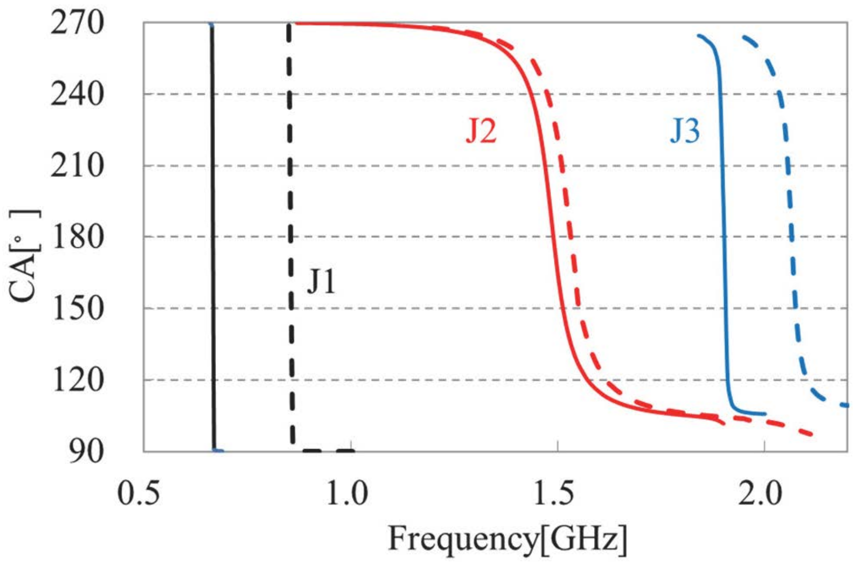


Fig. 2. Characteristics angles of the two-notch antenna.

I have the following questions on this paper:

1. Assuming that we are deigning the antenna for a "single" frequency (we assume that the design frequency is 1.5 GHz though the paper does not explicitly mention it) to realize the desired bidirectional pattern, why do we worry about the other modes since, according to Fig.2, these modes "resonate" at frequencies far away and when their bandwidths is very narrow?
2. If the radiation patterns of the modes are for different frequencies, how do the authors propose to combine them to realize the desired pattern?
3. If only the Mode-2 is to be used to realize the pattern, why spend so much time discussing the other modes that "resonate" far away from the operating frequency?

4. What criterion is used to determine the resonances of the CMs—is it their CA characteristics? The paper does not explain.
5. The paper explicitly mentions that the CMs are derived for the antenna geometry ‘*in the absence of the feed.*’ How do they figure out where to excite which modes, especially when the feed is located as shown in Fig.1 above (small circle at the center)? The paper does not explain.
6. I assume that every time they modify the antenna geometry they get new “resonance” frequencies. What is the strategy for changing the geometry of the antenna and what is the goal? Is it to get the desired pattern with a single mode, ay J_2? How do they know how to systematically choose the geometrical parameters of the antenna in order to make that happen? They claim that CMs give them a clue, but they don’t explain how.
7. How do they know where to locate the feed to excite the desired CMs? They did not explain this important point very clearly. (Also see Comment-5 above.)
8. It appears from the Abstract that the feed location was not changed in the deign process. Is that correct? If so, why?
9. What if the desired pattern cannot be achieved with a single CM, as is typically the case in practice? What is the design strategy for that scenario?

Submitted by: Antenna design engineer interested in the CM approach.