WIPL-D Software Validates Babinet's Principle

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Abstract

Antenna CAD software continues to increase the capacity to solve electromagnetic problems. Recently the WIPL-D software added a feature that permits the validation of the long standing antenna design principle, Babinet's Principle. This is truly unique and is indicative of how advanced antenna computer software has become. This paper presents a WIPL-D validation of Babinet's Principle

Babinet's Principle

John D. Kraus [1] Section 13-3, Babinet's Principle and Complementary Antennas, provides an excellent overview of Babinet's Principle and it application to antenna design.

Babinet's Principle: The field at any point behind a plane having a screen, if added to the field at the same point when the complementary screen is substituted, is equal to the field at the point when no screen is present.

Babinet's Principle applies to the case of perfectly absorbing screens and does not account for the vector nature of the electromagnetic field. H.G. Booker [2] extended and generalized Babinet's Principle to take into account the vector nature of the electromagnetic field. Booker's fundamental relationship is given by:

$$Z_A Z_{CA} = \frac{\eta^2}{4}$$

$Z_A = \text{Antenna Impedance}$

$Z_{CA} = \text{Impedance of Complementary Antenna}$

$\eta = \text{Free Space Impedance} = 120\pi \text{ Ohms}$

WIPL-D Validation of Babinet's Principle

The WIPL-D team [3] recently upgraded the WIPL-D software to version Pro 6.4, which includes the feature, Simulation of EM fields coupled through apertures in

infinite PEC/PMC planes. This feature can be used to compute the impedance for complementary antennas.

Figure 1 shows the WIPL-D configurations for the two complementary antennas. Figure 2 shows the comparison of the slot impedance computed based on Babinet's Principle and the slot impedance computed directly by WIPL-D. The agreement is remarkable. The difference is probably well within the accuracy of the modeling of the two complementary antennas.

Summary

When the writer of this article started his career in 1958 the key to good antenna design was the availability of a model shop that was able to produce antenna prototypes based on input mechanical sketches provided by the antenna design engineer. These prototypes were tested to determine their performance and were the first step in an iterative process in the development of an antenna with specific design characteristics. Today's antenna CAD software provides the means for completely bypassing this process. Final antenna designs can be based almost completely on antenna CAD software, greatly reducing the time and cost of antenna development.

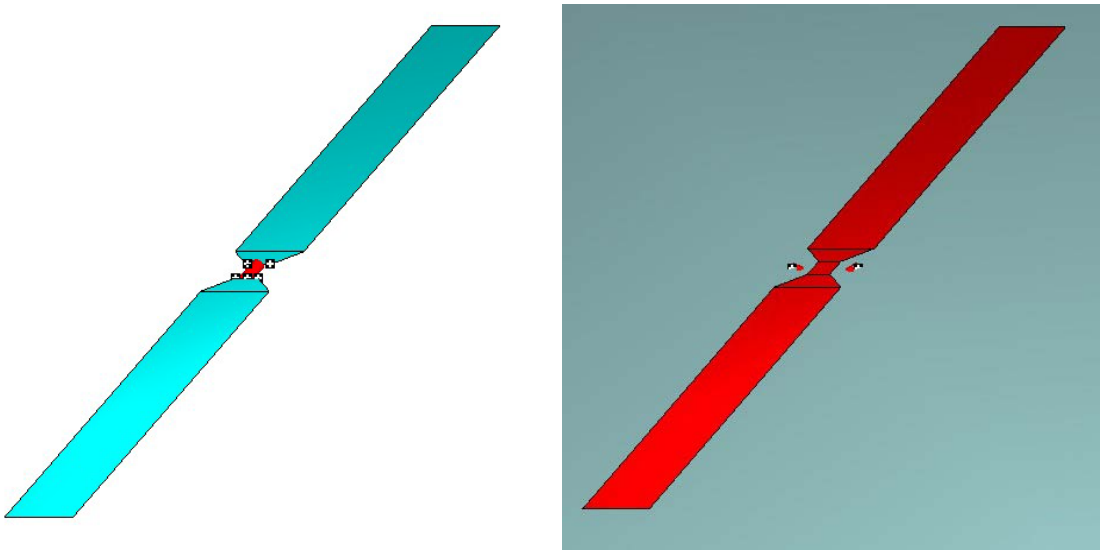
Validation of Babinet's Principle by the WIPL-D software adds a notch to the credibility and integrity of modern antenna CAD software.

References

[1] J.D. Kraus, "Antennas," McGraw-Hill, New York, 1950

[2] H.G. Booker, "Slot Aerials and Their Relation to Complementary Wire Aerials," J.I.E.E. (London), 93, Part IIIA, No. 4, 1946

[3] WIPL-D Pro v6.4, Software and User's Manual, WIPL-D d.o.o., Belgrade Serbia, 2007



(a) Metal plate dipole

(b) Complementary slot dipole (aperture in infinite PEC plane)

Figure 1 WIPL-D complementary antennas

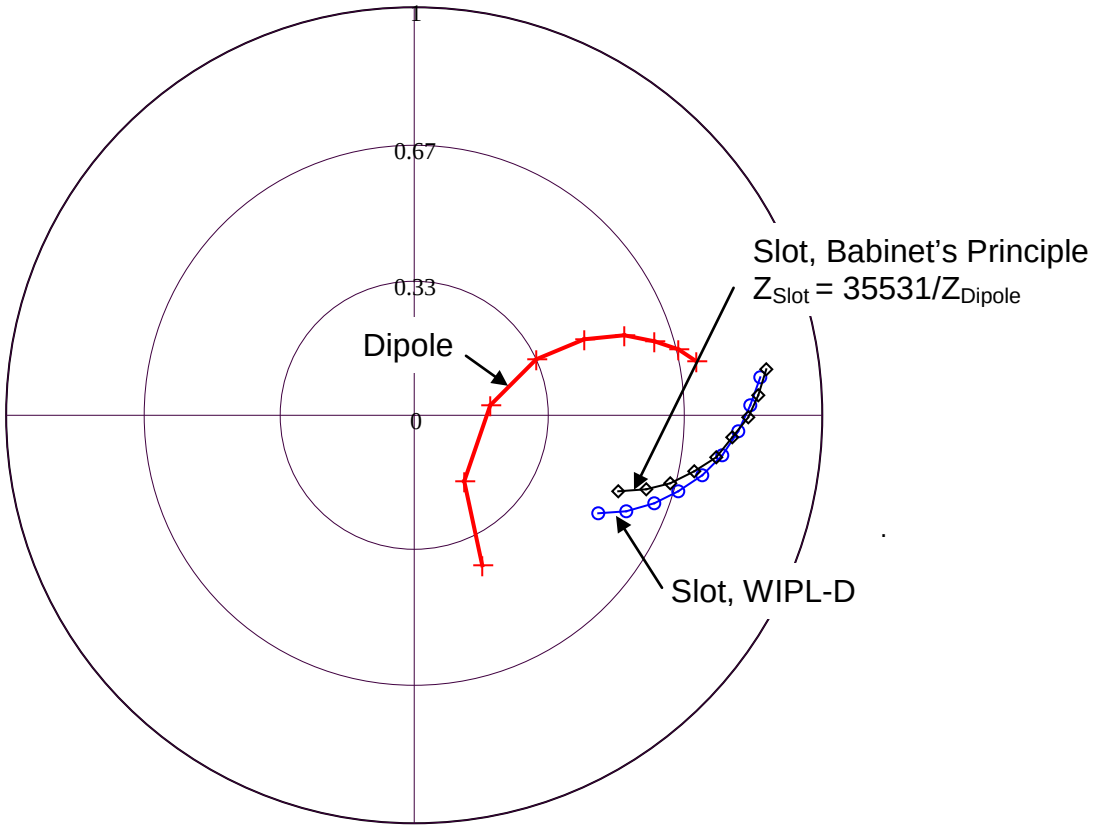


Figure 2 Comparison of WIPL-D and Babinet's Principle solutions for slot impedance (reflection chart normalized to 50 Ohms)