A Hybrid Model of a Monopole with a Coaxial Shielded Load

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The analysis of an antenna loaded with lumped circuit elements can be based on an efficient combination of Maxwell's equations (antenna) and circuit theory (loading circuit). But, if for example a wire antenna is loaded by a traditional thin-wire coil, the accuracy of the analysis may suffer due to the field coupling between the antenna members and the turns of the coil, which is not accounted for in either the antenna or circuit analysis per se. In such cases, the advantage in simplicity gained by using circuit theory to account for the presence of the lumped loading circuit elements is diminished by a loss in accuracy of the combined analysis. Shielding a coil, however, isolates its windings from the "stray fields," thereby ensuring coupling only at the terminals of the loading circuit and assuring the validity of computations based on the laws of circuit theory. Of course, there are other advantages realized by shielding tuning coils. The use of circuit laws to characterize load circuits, as opposed to appealing to Maxwell's equations to capture all significant effects, greatly simplifies analyses and reduces design efforts. But, on the other hand, the presence of the shield renders the characterization of a coil more complex. However, if the input impedance to a shielded load can be determined accurately, one may easily employ such loads for tuning purposes.

An accurate hybrid method is presented for analyzing a cylindrical antenna loaded with a shielded coil. The method consists of a computational procedure for solving the loaded cylindrical antenna integral equation and of a measurement procedure for accurately characterizing the shielded load. The structure of the shield ensures that the above mentioned accuracy-degrading effects of stray field coupling does not exist and the hybrid analysis technique fully accounts for the loading coil in the presence of its shield.

Measuring the input impedance of a shielded load presents several difficulties in practice, as standard connectors do not exist for interfacing the load with a network analyzer. A method to accurately measure the impedance looking into a shielded load, which involves interfacing the load with a measuring instrument by means of a two-port network, is described. The effects of the interfacing network on the measurements of the properties of a shielded load are removed from the data by invoking a simple transformation based upon two-port network theory and knowledge of the impedance parameters of the network. A calibration scheme is developed to determine the impedance parameters of the interfacing network. With data available to characterize the shielded load, one incorporates this load in the antenna integral equation and can obtain a solution that accurately accounts for the presence of loads in their shields along the antenna. Data from the hybrid solution are compared with those obtained from measurements made on a laboratory model. Accurate measurement of the input impedance of the model is facilitated by another de-embedding technique similar to that mentioned above.