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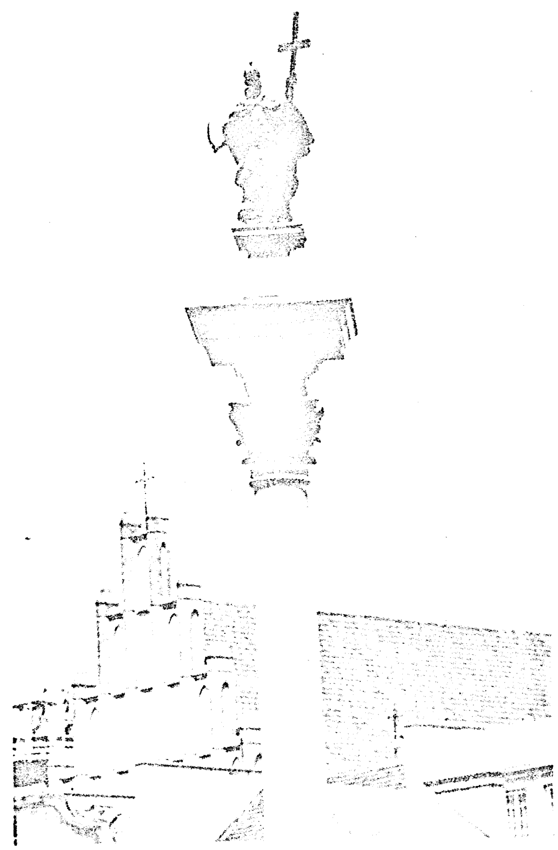

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VI.3 COMPUTER SIMULATION OF ELECTROMAGNETIC FIELD PROBLEMS AND OPTIMIZATION IN DESIGN

COMPUTER OPTIMIZATION IN ELECTROMAGNETIC DESIGN by J.W. Bandler

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Computer-oriented numerical optimization methods are coming into their own as aids to solving both circuit and field problems. In such areas as linear, time-invariant circuit design and modelling, nonlinear circuit analysis and optimization, and in the solution of partial differential equations related to electromagnetic and other field problems, methods which may broadly be classified as optimization methods are in current use. Whenever a problem can be expressed in the form of minimization of an objective function of a number of variables subject to certain linear or nonlinear constraints we have an optimization problem. As is well known, optimal approximation is closely related to function minimization since the approximation is carried out with respect to a specified norm which has to be minimized.

Early work largely relied on direct search methods, i.e., methods which do not require derivatives. The pattern search method proposed by Hooke and Jeeves (1961) was, and remains, quite popular. The use of more efficient gradient methods of minimization such as the Fletcher-Powell (1963) method and the more recent Fletcher (1970) method require, effectively, analytical derivatives.

An increasingly large volume of publications have devoted themselves to obtaining useful sensitivity expressions as an aid to evaluating these derivatives. Stimulated by Director and Rohrer (1969), further work on sensitivity evaluation useful for high frequency and distributed circuits has been done. Sensitivity formulas in terms of voltage and current variables have been published by Bandler and Seviora (1970). Corresponding formulas useful when circuits are analyzed in terms of scattering variables have also been made available by these authors (1972).

Whether used in tolerance studies, device modelling or gradient evaluation for optimization, the principal advantage of the adjoint network method (considering first-order sensitivities) is that it indicates how all the required sensitivity information can be obtained from little extra effort than is usually required for calculating a particular network response. This is particularly true of linear, time-invariant systems studied in the frequency domain.

When a set of errors have to be reduced in a least pth or minimax sense some new techniques are available which have been tested in the microwave area. The grazor search method, which employs partial derivative information in conjunction with linear programming, has been developed by Bandler, Srinivasan and Charalambous (1972) for general nonlinear minimax approximation problems. Bandler and Charalambous (1971 and 1972) have developed, and tested successfully, least pth approximation, also designed for fairly general nonlinear functions, where extremely large values of p, typically 1000, but often greater than 1000000 are used to provide extremely near minimax approximations. Gradient minimization methods are also used here.

Many of the useful developments and applications of computer-oriented optimization methods have appeared or are to appear in the IEEE Transactions on Microwave Theory and Techniques. Two relevant reviews may, for example, be found: one in the August 1969 issue and one in the December 1970 issue. The first is on optimization methods, the second on adjoint networks.

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