GENERATION OF COMPUTER MODELS FOR THE EMC ANALYSIS AND DESIGN OF LARGE SYSTEMS

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ABSTRACT

The computer modelling of large systems such as ships, aircraft or spacecraft is usually cumbersome and error-prone. This paper describes an interactive computer aided system called DIDEC (Digitize, Display, Edit and Convert) that simplifies considerably the modelling process and can be implemented on a microcomputer such as an LSI 11/23. Features of the code are presented and its utility displayed by the modelling of a CP-140 aircraft.

OBJECTIVES

In the design of complex systems such as aircraft, spacecraft or ships, where many radiating and receiving systems are co-sited, it is important to establish that there is minimum interaction between them. This interaction, among many, may be evident in terms of an undesired effect on radiation patterns or of unwanted signal coupling. At frequencies where the total structure is less than several wavelengths long, radiation patterns of antennas and coupling between antennas can be computed by using computer programs such as NEC (1) or GEMACS (2). These computer codes apply an integral equation solution using the Method of Moments (3) to the equivalent computer model of the total structure. This model can consist of either a wire grid mesh or a network of surface patches. The resulting coupling values are needed for EMC system analysis programs such as DECAL/PECAL (4).

The development of the model, for these purposes is similar to that used for finite element analysis of structural loads. The computer model must be generated by the error-free specification of the co-ordinates of the start and end vertices of each wire or the vertices of each surface patch. If done manually, this is a laborious task for complex objects or for objects of considerable size. It is also error-prone.

This paper describes a computer-aided software system called DIDEC that was designed and implemented on an LSI-11/23 microcomputer as a systematic model development tool. The acronym DIDEC means, Digitize, Display, Edit and Convert. This paper describes the modelling process, some features of DIDEC and an example of its use in aircraft antenna analysis.

METHODOLOGY

The EMC analyst must be aware of the limitations of his art. In terms of the use of computer codes, this implies knowing the requirements and limits of the input data and awareness of those parameters of this data that will effect the "electromagnetic equivalance" or validity of the model. Thus for the development of a wire grid model, he must decide about the location of the wires, their number, their length and their diameter. The basic code requirements are that the start and end co-ordinates and the diameter of each wire be specified. For an aircraft model with some 350 wires, approximately 600 vertices must be scaled and tabulated on the respective views of the working drawings. Errors of overlap and discontinuity can frequently occur and these are not necessarily detected by the computer code itself. The DIDEC system was designed to simplify and accelerate this process, to make it less error-prone and to add an interactive dynamic dimension to the process which makes the validity criteria and model features more visible to the engineer.

The necessary first step in both the manual as well as the computer-aided process is the marking of vertices/wire on accurate dimensioned three-view drawings of the structure. The model designer then proceeds to 'digitize' the vertices on a digitizing tablet. The drawing is first calibrated by digitizing two known reference points and then the co-ordinates of each point are determined sequentially: X, Y co-ordinates from a top-view and Y, Z co-ordinates from a side view. Points can be linked automatically to form wires, or their linkage can be specified by listing their vertex numbers. At each stage of digitization of any section of the structure, the vertices and wires can be displayed in multi-port displays with selected views corresponding to the source drawings and/or isometric 3-D displays. Wires and vertices can be deleted or added as desired. For large symmetrical structures commands such as 'REFLECT' and 'MERGE' exploit symmetry and allow progressive build-up of a complex model from individual, manageably small sections. Color -coded 3-D displays can show each wire in a color that corresponds to a coded value of diameter or length. This provides meaningful visualization of these parameters as they relate to modelling criteria for variable sections of the model. If the model is suitable, a final command will automatically translate the internal files into a input data set that conforms to the format requirements of the computer code that is being used.

The DIDEC system was intended to have features and to use software standards that would allow its evolutionary development and to minimize the danger of its early obsolescence.

IMPLEMENTATION AND USE

The graphics software used in DIDEC is called DIGRAF (5). It conforms to the Core Graphics Standard (6) and is readily available to the university environment. The program itself is written in RT-11 Fortran IV in a highly structured way so that it could be effectively overlayed to fit within the limited memory space of the microcomputer.

The major portions of the model development process are illustrated in the first two figures. Figure 1 shows the individual portions of the aircraft that were digitized separately. They are displayed as separate files in one of the many viewport configurations that DIDEC allows. The fuselage section in the upper left display port was obtained by digitizing one half of the fuselage in top and side-view drawings and by using the REFLECT command to generate the whole section. The horizontal stabilizers, shown in the lower right display port were formed also by using the REFLECT command.

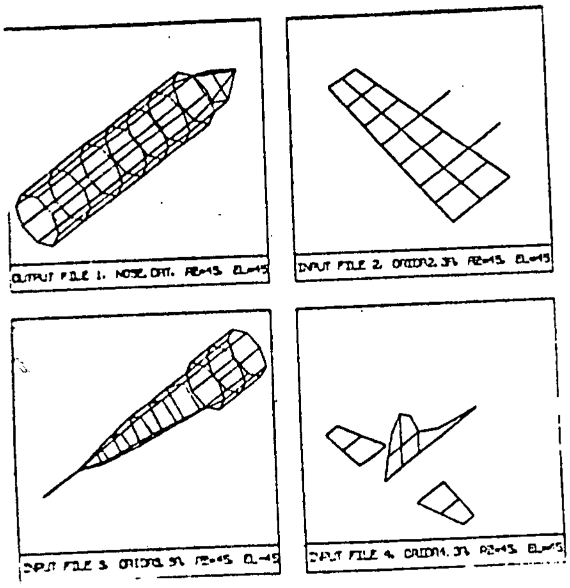


Figure 1. Individual Sections of Aircraft Structure

By a subsequent set of operations, the wing was reflected and merged with the fuselage and then the remaining sections were merged to form the complete aircraft model shown in Figure 2. A scaling command was used when necessary to keep the display of the merged sections within the limits of the display port. Fig. 2 also shows separate views of the aircraft simultaneously with the isometric display. Such views are useful for comparisons with the original aircraft drawings. If desired, they can be displayed individually in single ports over the entire screen. Illustrations in the oral paper show the simple mnemonic commands that produce these displays. The color coding of the wires as to diameter and length is also shown. Finally the NEC command translates the model description data into the proper format as in input data file for the NEC computer code.

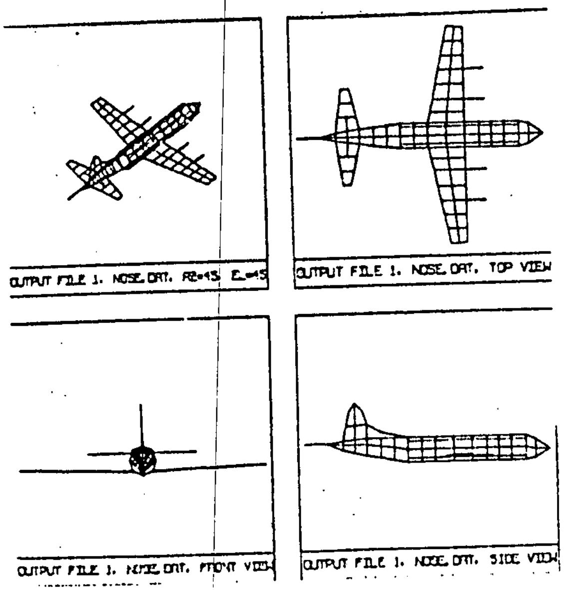
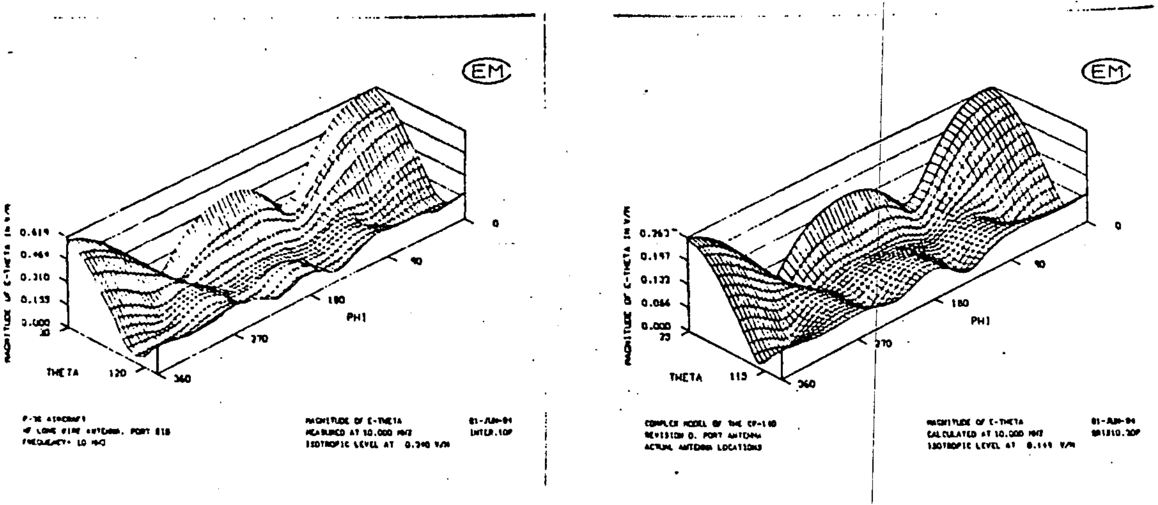


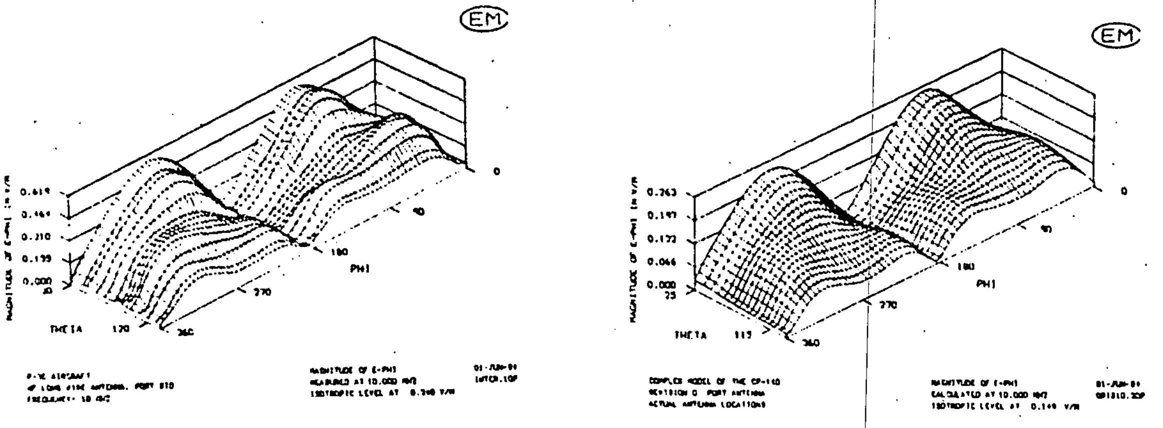
Figure 2. Merged Sections and Separate Views

This complex model, carefully developed using the DIDEC system, has produced the computed radiation patterns shown in Figure 3 for 10 MHz. Here both the computed and measured results are displayed in a hidden-line format that allows simultaneous display of the entire set of available conical patterns. Separate displays are shown for the E-theta and E-phi polarizations. Similar agreement was obtained throughout the 2-30 MHz HF frequency range. Calculations of antenna-to-antenna coupling also track experimental measurement results.



(a) Measured E_θ

(b) Computed E_θ



(c) Measured E_ϕ

(d) Computed E_ϕ

Figure 3 Radiation Patterns, HF Antenna, 10 MHz
CP-140 Aircraft - Hidden Line Format

CONCLUSION

The development of complex computer models by hand is a tedious and error-prone process. The DIDEC interactive model building system accelerates the process of developing wire-grid models but also it does so without mechanical measurement errors and provides constant insight into the significant parameters that are important to the success of electromagnetic models. Compared to the manual process, the time ratios are at least 20:1. The successful results obtained to-date indicate that it is a useful addition to the entire process of computer-based EMC analysis and design of large structures and complex systems.

ACKNOWLEDGEMENTS

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