CAL - Antennas
Computer-Aided Learning of Antennas

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ABSTRACT

CAL-ANTENNAS is a tool containing graphics (2D and 3D) and sounds coded in the Turbo Pascal 5.5 language, for the implementation of educational software on antennas. From the Units files, a database (frequency bands, antenna forms, antenna dimensions, formulae, characterising radiation) and a repertory of numerical methods (integration, graphs plotting, etc...) have been developed, complying with speed constraints. The necessary fundamental principles are contained in text files. Thus, this is one of the first structured software packages developed on the computer in the domain of antennas that treats the fundamental principles and the methodology of design.

This version of CAL-ANTENNAS for the microcomputer based on the Intel 386 and 486 Microprocessors contains more than a hundred illustrations.

I. INTRODUCTION

CAL-ANTENNAS is a teaching as well as a design tool. Several programs exist [2] - [4], [9] - [10] for the computer-aided study of either one type of antenna or one specific application of antennas. This software on the other hand is a structured book on antenna in a microcomputer. This version of the software for microcomputers based on the Intel 386 and 486 microprocessors is written in Turbo Pascal 5.5.

This software is meant first for student of higher education, since it is at that level that courses on antennas are generally taught. CAL - ANTENNAS may then be used effectively as a support.

This software is also meant for general and technical high school students, who will then be able to:
- make a classification of electromagnetic radiation,
- name antennas,
- determine the frequency ranges corresponding to each type of antenna based on what has been presented in several works [2] - [8].

Finally, this software is meant for radio-amateurs who will then be able to dimension their antennas.

CAL-ANTENNAS is a software comprising two main parts:
- an entirely illustrated course on antennas,
- a part to enable one to dimension antennas and to determine their characteristics following theories presented in several reference works [2] - [5]

2. THE MAIN MENU

The main menu has five options:
Help, Lesson, Design, Reference, Exit.
Once you type ANTENNA, the display on the screen is:

<table>
<thead>
<tr>
<th>Help</th>
<th>Lesson</th>
<th>Design</th>
<th>Reference</th>
<th>Edit</th>
</tr>
</thead>
<tbody>
<tr>
<td>[]</td>
<td></td>
<td></td>
<td></td>
<td>[]</td>
</tr>
</tbody>
</table>

<Esc> = Previous Menu  Up, Down, Left, Right = Options  <Enter> = Val

2.1 The MENU Help

This menu gives the user information on CAL-ANTENNAS commands. This will help him get acquainted with the software.

As soon as you validate the option Help, you fall on the first help page. To move into the next page you must depress the <Enter> key. To get out of the Help menu you press the <Esc> key.

The choice of an option can be made in two ways:
- by typing the initial of the option chosen,
- by depressing one of the following keys: -->, <--.

The choice can also be carried out with the keys: Up, Down.

The validation of an option is made by depressing the <Enter> key.
- <Enter> enables you to move onto the next page.
- <Esc> enables you to exit and return to previous option.

In the exercises sub menu, the F1 key enables you to have the computer answer; the F2 enables you to make the demonstration.

2.2 The MENU Lesson

The menu Lesson is an illustrated course and exercises on antennas. The course is made of different parts. Each part is directly accessible. To make it easy to understand the course, each part is illustrated by a sketch. Once lesson is selected, the display on the screen is the following:
The sub Menu Lecture

Once Lecture is selected, the display on the screen is the following:

(i) If the choice is I - History, you have on the screen the history of the means of communication whose illustrations are reproduced in figures 1 to 8. Figure 2 reflects African cultures, which shows the adaptability prospects of the software CAL-ANTENNAS.

(ii) If the choice is II - Radioelectricity, the display on the screen is the following:

Each option allows you to gain direct access to a given part of the lesson on radioelectricity. For example, option 2, Classification gives you the classification of electromagnetic radiation. Figures 9 to 15 are some of the illustrations of this part of the lesson on radioelectricity.

(iii) If the choice is III - Antennas, the display on the screen is the following:
The options 1 - Definition and 4 - Attenuator and repartitioner enable you to gain direct access to two parts of the lesson. Illustration of this options are shown in Figures 16 to 18.

On the other hand, each of the other three options has a submenu.

(∗) If the choice is 2 - Principle, the display on the screen is :

Figures 19 to 28 reproduce some of the illustrations of the lesson on the principle of antennas. The supply of an antenna is illustrated by Figures 24 to 28, taking into account the many possible cases of this principle. That also is CAL-ANTENNAS, an evolutionary data bank.

(∗∗) If the choice is 3 - Characteristics, the screen shows :
Figures 29 to 37 illustrate the part of the Lesson dealing with the characteristics of antennas. Each of these is accompanied in CAL-ANTENNAS by appropriate explanations.

(*** ) If the choice is 5- Types of antennas, the screen shows :
CAL-ANTENNAS illustrates a few types of antennas as reproduced here in Figures 38 to 47. With this software it is possible to complete and/or improve these illustrations if necessary.

2°) The sub Menu Exercises
Once Exercises is validated, the display on the screen is the following:

<table>
<thead>
<tr>
<th>Fundamental</th>
<th>Dipoles</th>
<th>Aperture</th>
<th>Reflectors</th>
<th>Microstrips</th>
</tr>
</thead>
<tbody>
<tr>
<td>PgUp=Previous</td>
<td>F1=Answer</td>
<td>F2=Explanation</td>
<td>F10=Exit</td>
<td>&lt;Enter&gt; = Introduce your answer</td>
</tr>
<tr>
<td>Pgdown=Next</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(*) If the choice is Fundamental, the display on the screen is for example:

<table>
<thead>
<tr>
<th>Fundamental</th>
<th>Dipoles</th>
<th>Aperture</th>
<th>Reflectors</th>
<th>Microstrips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercise 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Give Maxwell equations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PgUp=Previous</td>
<td>F1=Answer</td>
<td>F2=Explanation</td>
<td>F10=Exit</td>
<td>&lt;Enter&gt; = Introduce your answer</td>
</tr>
<tr>
<td>Pgdown=Next</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(**) If the choice is Dipoles, the display on the screen is for example:

<table>
<thead>
<tr>
<th>Fundamental</th>
<th>Dipoles</th>
<th>Aperture</th>
<th>Reflectors</th>
<th>Microstrips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercise 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A lossless resonant half-wavelength dipole antenna, with input impedance of 73 ohms, is to be connected to a transmission line whose characteristic impedance is 50 ohms. Assuming that the pattern of antenna is given approximately by ( U = B \sin^3 \theta ); Find the overall gain.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PgUp=Previous</td>
<td>F1=Answer</td>
<td>F2=Explanation</td>
<td>F10=Exit</td>
<td>&lt;Enter&gt; = Introduce your answer</td>
</tr>
<tr>
<td>Pgdown=Next</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The user can introduce his answer. If the answer is correct, he will be congratulated. Otherwise he will be asked to try again. If the user can't find the solution, he can use the F1 key to have the computer answer, or the F2 key for the computer demonstration of the exercise.

2.3 The MENU Design

The Menu Design utilizes known theoretical developments [1] - [4]. [7], [8], [11] to characterize a given type of antenna. CAL-ANTENNAS may thus be considered as a complement to the many works that do not give numerical applications of the theory and/or do not illustrate the latter with appropriate sketches. The menu Design proposes, for the frequency range chosen, the corresponding antenna. It is also determines its characteristics and its dimensions. When you validate the option Design, the screen shows:

<table>
<thead>
<tr>
<th>Help</th>
<th>Lesson</th>
<th>Design</th>
<th>Reference</th>
<th>Exit</th>
</tr>
</thead>
<tbody>
<tr>
<td>APPLICATIONS</td>
<td>MEASUREMENTS</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1st) The Sub Menu Applications

When you validate the option Applications, the screen shows:

<table>
<thead>
<tr>
<th>Help</th>
<th>Lesson</th>
<th>Design</th>
<th>Reference</th>
<th>Exit</th>
</tr>
</thead>
<tbody>
<tr>
<td>APPLICATIONS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| I. Frequency range |
| II. Type of antenna |
| III. Dimensions |
| IV. Characteristics |

Following the choice of the option you get a display of the frequency ranges and the wavelengths for the corresponding band. For example, (i) if your choice is 1 - Radio - broadcast bands, the display on the screen is that shown in the Figure 48.

<table>
<thead>
<tr>
<th>Help</th>
<th>Lesson</th>
<th>Design</th>
<th>Reference</th>
<th>Exit</th>
</tr>
</thead>
<tbody>
<tr>
<td>APPLICATIONS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>I. Frequency range</th>
</tr>
</thead>
</table>

| 1. Radio - broadcast bands |
| 2. Tropical bands |
| 3. Radio-amateur bands |
| 4. Short-waves bands |
| 5. TV - FM |
The validation of the frequency range sends you directly back to the preceding screen display. Thus you can see the type of antenna that correspond to the frequency range chosen.

(ii) If the choice is II - Type of antenna, the screen shows the antennas that correspond to the frequency range chosen. A message will be displayed if a frequency range has not be chosen before hand. The set of Figures (48, 49, 50) and (51, 52, 53) illustrates the choice of a frequency band as well as the type of antennas associated with it. Once validated, the antenna chosen is shown on the screen on a large scale.

(iii) If the choice is III - Dimensions, you have on the screen the antenna chosen and its dimensions. Figures 54 and 55 are illustration samples.

(iv) If the choice is IV - Characteristics, the screen shows:

<table>
<thead>
<tr>
<th>Help</th>
<th>Lesson</th>
<th>Design</th>
<th>Reference</th>
<th>Exit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>APPLICATIONS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>I. Frequency range</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>II. Type of antenna</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>III. Dimensions</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IV. characteristics</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>L. Parameters</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. Radiation pattern</td>
<td></td>
</tr>
</tbody>
</table>

(*) If the choice is I - Parameters, you have on the screen the parameters (Bandwidth, Radiation Power, Directivity, Radiation Resistance) of the antenna chosen. This is illustrated in figures 56, in the case of successive choices of Figures 48, 49 and 54.

(**) If the choice is 2 - Radiation Pattern, the screen shows:

<table>
<thead>
<tr>
<th>Help</th>
<th>Lesson</th>
<th>Design</th>
<th>Reference</th>
<th>Exit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>APPLICATIONS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>I. Frequency range</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>II. Type of antenna</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>III. Dimensions</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IV. characteristics</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>L. Parameters</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. Radiation pattern</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>a. Cartesian coordinates 2D</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>b. Polar coordinates</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>c. Cartesian coordinates 3D</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>d. Spherical coordinates</td>
<td></td>
</tr>
</tbody>
</table>
For each option the radiation pattern of the antenna chosen is drawn in one of the four coordinate systems. Figures 57 to 72 are illustrations for T, helical, pyramidal horn and quarter wave vertical antennas respectively.

2°) The Sub Menu Measurements
This is not ready in this version of CAL-ANTENNAS.

2.4 The menu References
Once References is validated, the display on the screen is the following:

(*) If the choice is REGISTRATION, the display on the screen is:

(*** If the choice is RESEARCH, the display on the screen is:

Once Book is validated in the research menu, the display on the screen is for example the following:
2.5 The MENU Exit

It is the menu that enables you to get out of CAL-ANTENNAS.

3 CONCLUSION

CAL-ANTENNAS has five menus which are:

- Help, - Lesson, - Design, - Reference, - Exit

The menu Help gives the CAL-ANTENNAS commands.

The menu Lesson is a microcomputer aided course. It is a course which may be used by a teacher to illustrate a course on antennas: it is a teaching tool.

The menu Design enables one to know, for each frequency range, the characteristics of the corresponding antenna. It is of interest to:

- the teacher who will be able to use it as teaching material,
- the student who will be able to name antennas, give their characteristics and establish a correspondence between type of antenna and frequency range.
- the radio-amateur who would like to build his own antenna.

The menu References is a data base of antennas bibliography.

The prospects for CAL-ANTENNAS are the following:

- to improve the quality and the quantity of the data bank of illustrations,
- to complete the part lesson by adding exercises, as well as books, video cassette, and software references, including photos,
- to transform CAL-ANTENNAS into CAL-ANTENNAS and PROPAGATION in order to deal in more details with the topic of free and guided propagation.
- to take into account particular applications: radar, micro-wave heating, etc.
4. REFERENCES

[9] Horizontal dipole arrays over imperfect ground - Programs in BASIC. International Telecommunication Union, General Secretariat (Sales section), Place des Nations, CH-1211.
Figure 1 The mouth to ear conversation

Figure 2 The drum

Figure 3 The smoke signals

Figure 4 The telephone

Figure 5 The pennant

Figure 6 The blinking light

Figure 7 The siren

Figure 8 The pyrotechnical signals

Figure 9 Classification of electromagnetic waves
Figure 10  Ground wave
Figure 11  Straight line wave
Figure 12  Sky wave

Figure 13  Medium of propagation of electromagnetic waves
Figure 14  The zones of ionosphere

Figure 15  Frequency allocation: short-waves bands

Figure 16  Emission /Reception of electromagnetic waves
Figure 17  Distributor
Figure 18  Attenuator
Figure 19  
Radiation diagram formulation of a dipole

Figure 20  
An example of the polarization of wave: rectilinear polarization

Figure 21  
Radiation diagram in polar coordinates

Figure 22  
The shape of current and voltage along a resonant antenna

Figure 23  
Ground effect

Figure 24  
Two wire supply

Figure 25  
Coaxial line supply

Figure 26  
Other forms of supply

Figure 27  
Center sound supply of an antenna
Figure 37  Antenna matching

Figure 38  T antenna

Figure 39  Vertical antenna

Figure 40  Log-periodic antenna

Figure 41  Helical antenna

Figure 42  Quarter wave vertical antenna

Figure 43  YAGI antenna

Figure 44  Pyramidal horn

Figure 45  Parabolic reflector with center feed horn
Figure 46 Parabolic reflector with depored feed horn

Figure 47 Microstrip antenna

Figure 48 Frequency ranges of radio-broadcast bands

Figure 49 Radio-broadcast band types of antenna

Figure 50 Choice of a radio-broadcast band antenna

Figure 51 Frequency ranges in the radio-amateur band

Figure 52 Radio-amateur band types of antenna

Figure 53 Choice of radio-amateurs band antenna

Figure 54 Design of a radio broadcast band antenna
Figure 55 Design of a radio-amateur band antenna

Figure 56 Parameters of a T antenna

Figure 57 T antenna radiation diagram in cartesian coordinates 2D

Figure 58 T antenna radiation diagram in polar coordinates

Figure 59 T antenna radiation diagram in cartesian coordinates 3D

Figure 60 T antenna radiation diagram in spherical coordinates

Figure 61 Helical antenna radiation diagram in cartesian coordinates

Figure 62 Helical antenna radiation diagram in polar coordinates

Figure 63 Helical antenna radiation diagram in cartesian coordinates
Figure 64 Helical antenna radiation diagram in spherical coordinates

Figure 65 Pyramidal horn radiation diagram in cartesian coordinates 2D

Figure 66 Pyramidal horn radiation diagram in polar coordinates

Figure 67 Pyramidal horn radiation diagram in cartesian coordinates 3D

Figure 68 Pyramidal horn radiation diagram in spherical coordinates

Figure 69 Quarter wavelength antenna radiation diagram in cartesian coordinates 2D

Figure 70 Quarter wavelength vertical antenna radiation diagram in polar coordinates

Figure 71 Quarter wavelength antenna radiation diagram in cartesian coordinates 3D

Figure 72 Quarter wavelength antenna radiation diagram in spherical coordinates