# ELEC 621 NUMERICAL TECHNIQUES IN ELECTROMAGNETICS

Wolfgang J.R. Hoefer, Professor

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Fall 2005

## Description of Typical Projects

**Project 1 Finite Difference Method in the Frequency Domain (FD)**

**Description:**

**Implement and compile a FD program in the language of your choice for the following purposes:**

1) To compute the capacitance of a shielded parallel-plate transmission line (Textbook pp. 32 to 35).
2) To compute the capacitance of a square coaxial line.

**Prepare a 45 minute presentation describing**

1) The important features of the algorithm that forms the basis of these programs,
2) The structure of the programs,
3) Any particular difficulties encountered when studying, compiling and running the programs,
4) Typical results obtained.
5) Draw your conclusions (formulate your own observations, comments, describe advantages, disadvantages, sources of error, pitfalls)

**Be prepared to answer questions from your fellow students!**

**Summarize your presentation in a succinct report (maximum 6 typed pages). The ideal would be if you could distribute that report to all students before your presentation. Also prepare listings of the programs in ASCII format on a diskette.**

Text: Richard C. Booton, Jr.
*Computational Methods for Electromagnetics and Microwaves*
John Wiley & Sons, New York, 1992

## Date of Presentation:

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## Project Description

**Project 2 Finite Difference Method in the Time Domain (FD-TD)**

**Description:**

**Implement and compile the following FORTRAN programs:**

1) FD-TD program to compute the TM mode spectrum in a rectangular waveguide Textbook pp. 65 to 68).
2) FD program to compute the field of the TM modes in a rectangular waveguide (Textbook pp. 47 to 50).

**Prepare a 45 minute presentation describing**

1) The important features of the algorithm that forms the basis of these programs,
2) The structure of the program,
3) Any particular difficulties encountered when studying, compiling and running the programs,
4) Typical results obtained.
5) Draw your conclusions (formulate your own observations, comments, describe advantages, disadvantages, sources of error, pitfalls)

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## Project Description

**Project 3 Transmission Line Matrix Method (TLM)**

**Description:**

**Implement and compile the following program in the language of your choice**

2D-TLM program for TM type two-dimensional electromagnetic wave modeling. in parallel plate and rectangular $TE_{n0}$ waveguides (Reference [1] pp. 573 -580.)

**Prepare a 45 minute presentation describing**

1) The important features of the algorithm that forms the basis of this program,
2) The structure of the program,
3) Any particular difficulties encountered when studying, compiling and running the program,
4) Typical results obtained.
5) Draw your conclusions (formulate your own observations, comments, describe advantages, disadvantages, sources of error, pitfalls)

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**Summarize your presentation in a succinct report (maximum 6 typed pages). The ideal would be if you could distribute that report to all students before your presentation. Also prepare listings of the programs in ASCII format on a diskette.**

Reference [1] Tatsuo Itoh (Editor)
*Numerical Techniques for Microwave and Millimeter-Wave Passive Structures*
John Wiley & Sons, New York, 1989

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## Project Description

**Project 4 Finite Element Method (FEM)**

**Description:**

**Implement and compile the following program in the language of your choice:**

1) a FEM program to compute the capacitance of a shielded parallel-plate transmission line (Textbook pp. 94 to 97).

**Prepare a 45 minute presentation describing**

1) The important features of the algorithm that forms the basis of this program,
2) The structure of the program,
3) Any particular difficulties encountered when studying, compiling and running the program,
4) Typical results obtained.
5) Draw your conclusions (formulate your own observations, comments, describe advantages, disadvantages, sources of error, pitfalls)

**Be prepared to answer questions from your fellow students!**

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## Project Description

**Project 5 Method of Moments (MOM)**

**Description:**

**Implement and compile the following program in the language of your choice:**

MoM program (See Prof. Hoefer for details)

**Prepare a 45 minute presentation describing**

1) The important features of the algorithm that forms the basis of this program,
2) The structure of the program,
3) Any particular difficulties encountered when studying, compiling and running the program,
4) Typical results obtained.
5) Draw your conclusions (formulate your own observations, comments, describe advantages, disadvantages, sources of error, pitfalls)

**Be prepared to answer questions from your fellow students!**

**Summarize your presentation in a succinct report (maximum 6 typed pages). The ideal would be if you could distribute that report to all students before your presentation. Also prepare listings of the programs in ASCII format on a diskette.**

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## Project Description

**Project 6 Spectral Domain Method (SDM)**

**Description:**

**Implement and compile the following PASCAL program:**

Spectral Domain Program program for the characteristics of bilateral finline (See Prof. Hoefer for details).

**Prepare a 45 minute presentation describing**

1) The important features of the algorithm that forms the basis of this program,
2) The structure of the program,
3) Any particular difficulties encountered when studying, compiling and running the program,
4) Typical results obtained.
5) Draw your conclusions (formulate your own observations, comments, describe advantages, disadvantages, sources of error, pitfalls)

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**Summarize your presentation in a succinct report (maximum 6 typed pages). The ideal would be if you could distribute that report to all students before your presentation. Also prepare listings of the programs in ASCII format on a diskette.**

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*Computational Methods for Electromagnetics and Microwaves*
John Wiley & Sons, New York, 1992

Wolfgang J.R. Hoefer
Course notes on Spectral Domain Method.

## Date of Presentation:

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## Project Description

**Project 7 Transverse Resonance Method (TRM) and Mode Matching**

**Description:**

**Implement and compile the following program in the language of your choice:**

Transverse Resonance Program for the characteristics of ridged waveguide
(See Prof. Hoefer for details).

**Prepare a 45 minute presentation describing**

1) The important features of the algorithm that forms the basis of this program,
2) The structure of the program,
3) Any particular difficulties encountered when studying, compiling and running the program,
4) Typical results obtained.
5) Draw your conclusions (formulate your own observations, comments, describe advantages, disadvantages, sources of error, pitfalls)

**Be prepared to answer questions from your fellow students!**

**Summarize your presentation in a succinct report (maximum 6 typed pages). The ideal would be if you could distribute that report to all students before your presentation. Also prepare listings of the programs in ASCII format on a diskette.**

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## Project Description

**Project 8 Finite Difference Method (FD)**

**Description:**

**Compute the electrostatic potential in a dielectric sphere subject to a static electric field**

1) Write a two-dimensional FD program in Cartesian coordinates to solve Laplace's equation.
2) Using this program, find the potential distribution in the geometry given on the attached page. Use staircase approximation of curved boundaries.

**Prepare a 45 minute presentation describing**

1) The important features of the algorithm that forms the basis of your program,
2) The structure of the program,
3) Any particular difficulties encountered when writing, compiling and running the program,
4) Results obtained. Prepare appropriate tables, graphs, and field distribution plots inside and outside the cell. Include some validation data.
5) Draw your conclusions (formulate your own observations, comments, describe advantages, disadvantages, sources of error, pitfalls)

**Be prepared to answer questions from your fellow students!**

**Summarize your presentation in a succinct report (maximum 10 typed pages). The ideal would be if you could distribute that report to all students before your presentation. Also prepare listings of the programs in ASCII format on a diskette.**

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## Project Description

**Project 9 Finite Difference Method in the Time Domain (FD-TD)**

**Description:**

**Compute the first three cutoff frequencies of an antipodal finline with FD-TD**

1) Write a two-dimensinonal FD-TD program with Discrete Fourier Transform Capability.

2) Using this program, find the first three cutoff frequencies of the antipodal finline geometry given on the attached page.

**Prepare a 45 minute presentation describing**

1) The important features of the algorithm that forms the basis of your program,
2) The structure of the program,
3) Any particular difficulties encountered when studying, compiling and running the program,
4) Results obtained. Prepare appropriate tables, graphs, and (optional) field distribution for the three first modes at cutoff. Include some validation data.
5) Draw your conclusions (formulate your own observations, comments, describe advantages, disadvantages, sources of error, pitfalls)

**Be prepared to answer questions from your fellow students!**

**Summarize your presentation in a succinct report (maximum 10 typed pages). The ideal would be if you could distribute that report to all students before your presentation. Also prepare listings of the programs in ASCII format on a diskette.**

Text: Richard C. Booton, Jr.
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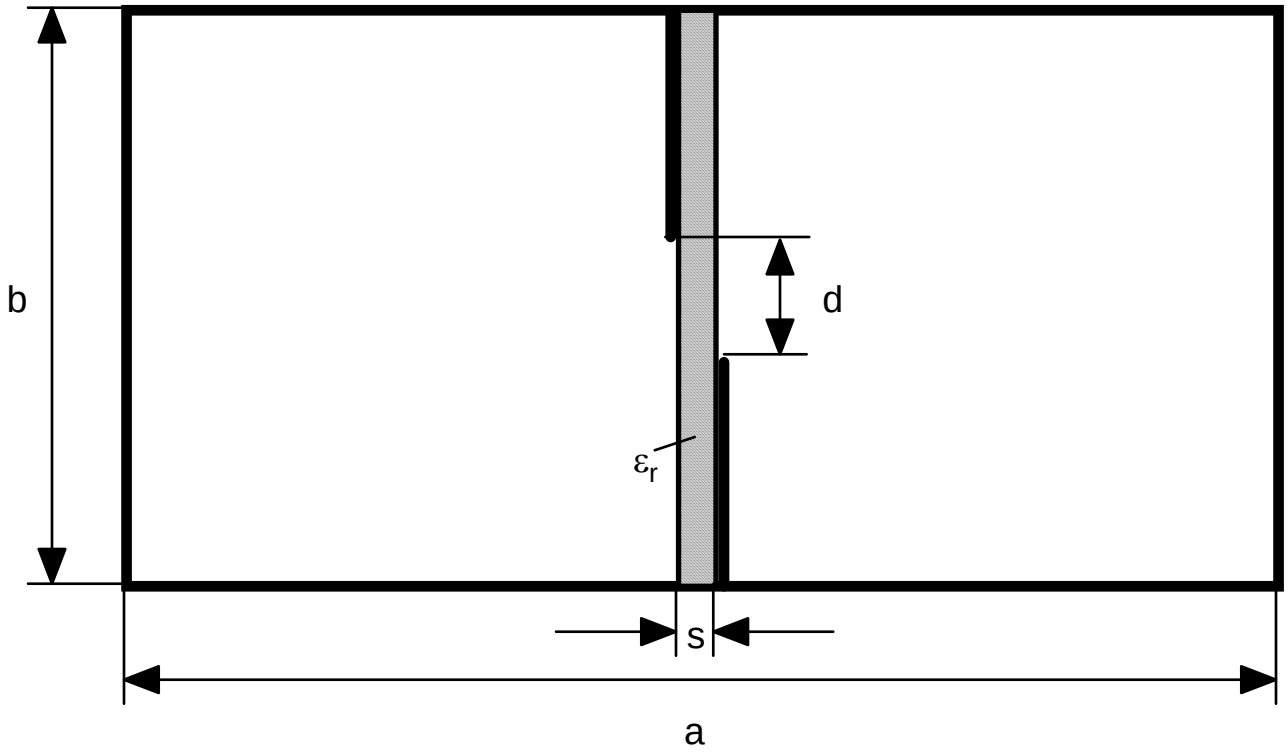
John Wiley & Sons, New York, 1992

## Date of Presentation: tbd

Geometry of Antipodal Finline




Dimensions

a = 7.112 mm
b = 3.556 mm
s = 0.254 mm
d/b = 0.25; 0; - 0.25
$\varepsilon_r$ = 2.2

The substrate is centered in the WR(28) enclosure.
The metal fins on the two sides of the substrate are infinitely thin and perfectly conducting.
The walls are also perfect conductors.

Note that modes at cutoff can be either of TE or TM type.

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## Project Description

**Project 10 Transmission Line Matrix Method (TLM)**

**Description:**

**Compute the first three cutoff frequencies of a dielectric-loaded coax line**

1) Write a two-dimensinonal TLM program for cylindrical coordinates with Discrete Fourier Transform Capability.
2) Using this program, find the first three cutoff frequencies of the coaxial geometry given on the attached page.

**Prepare a 45 minute presentation describing**

1) The important features of the algorithm that forms the basis of your program,
2) The structure of the program,
3) Any particular difficulties encountered when studying, compiling and running the program,
4) Results obtained. Prepare appropriate tables, graphs, and (optional) field distribution for the three first modes at cutoff. Include some validation data.
5) Draw your conclusions (formulate your own observations, comments, describe advantages, disadvantages, sources of error, pitfalls)

**Be prepared to answer questions from your fellow students!**

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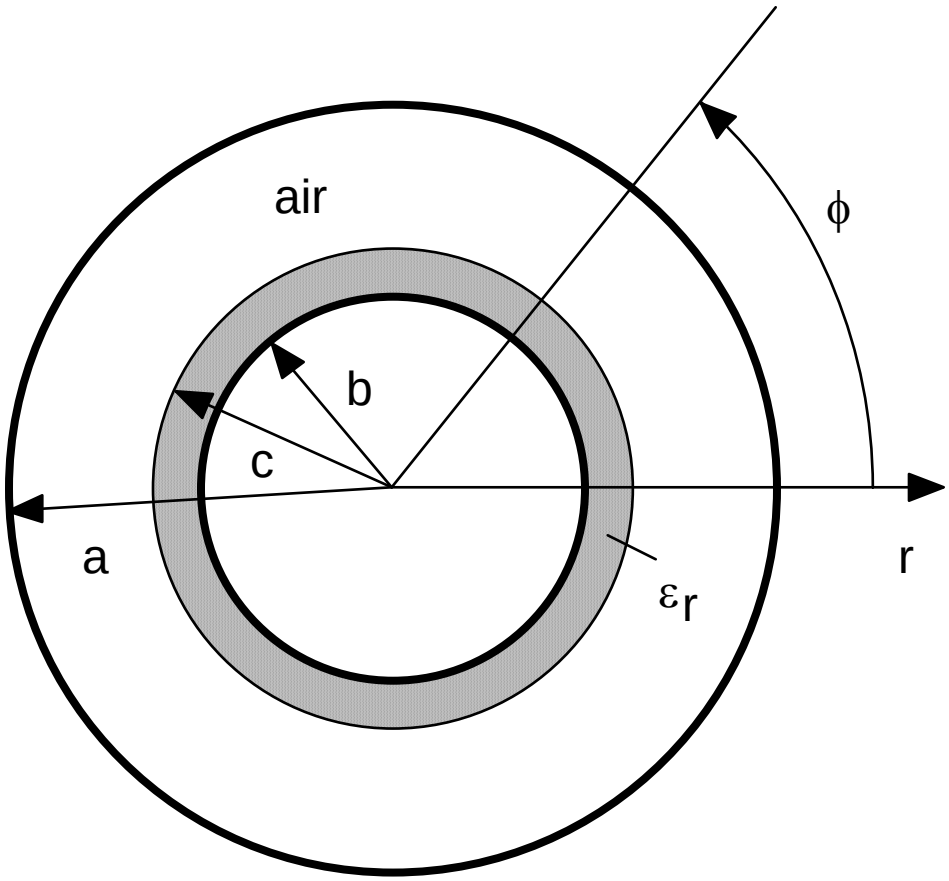
Reference. D.A. Al-Mukhtar and J. E. Sitch, ``Transmission-Line Matrix Method with Irregularly Graded Space", Proc. IEE, vol. 128, Pt.H, no. 6, pp. 299-305, Dec.1981.

## Date of Presentation: tbd

Geometry of partially dielectric-loaded coaxial line




Dimensions:

a = 2 mm
b = 1 mm
c = 1.2 mm
$\varepsilon_r = 4$

Note: Modes at cutoff can be of TE or TM type.

All walls and dielectrics are lossless.

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## Project Description

**Project 11 Finite Element Method (FEM)**

**Description:**

**Compute the first three cutoff frequencies of an antipodal finline with FEM**

1) Write a two-dimensinonal FEM program for eigenproblem solution.
2) Using this program, find the first three cutoff frequencies of the antipodal finline geometry given on the attached page.

**Prepare a 45 minute presentation describing**

1) The important features of the algorithm that forms the basis of this program,
2) The structure of the program,
3) Any particular difficulties encountered when studying, compiling and running the program,
4) Results obtained. Prepare appropriate tables, graphs, and (optional) field distribution for the three first modes at cutoff. Include some validation data.
5) Draw your conclusions (formulate your own observations, comments, describe advantages, disadvantages, sources of error, pitfalls)

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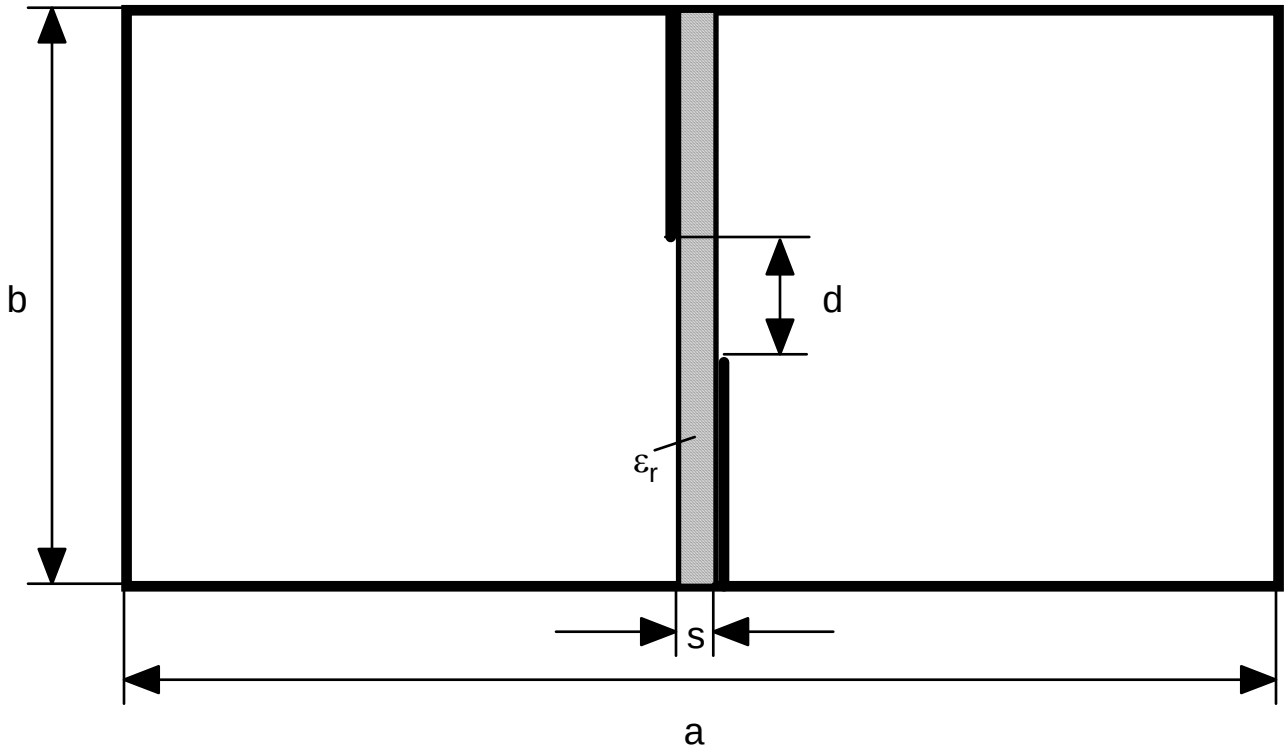
## Date of Presentation: tbd

Geometry of Antipodal Finline




Dimensions

a = 7.112 mm
b = 3.556 mm
s = 0.254 mm
d/b = 0.25; 0; - 0.25
$\varepsilon_r$ = 2.2

The substrate is centered in the WR(28) enclosure.
The metal fins on the two sides of the substrate are infinitely thin and perfectly conducting.
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## Project Description

**Project 12 Method of Moments (MOM)**

**Description:**

**Implement and compile a Method of Moments program in two dimensions:**

Write and implement a MoM program and solve Computer Project 7-2 described on page 129 in the Text below.

**Prepare a 45 minute presentation describing**

1) The important features of the algorithm that forms the basis of this program,
2) The structure of the program,
3) Any particular difficulties encountered when studying, compiling and running the program,
4) Results obtained. Prepare appropriate tables, graphs, and (optional) field distribution in the vicinity of the plate. Include some validation data.
5) Draw your conclusions (formulate your own observations, comments, describe advantages, disadvantages, sources of error, pitfalls)

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