031307-8-T

USERS MANUAL FOR FEMA-PRISM (VERSION 2)

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Changes from the previous version:

1. Mesher and the analysis code has been seperated. Mesher is called "mesh.f" and the code is called "FEMA-PRISM.f".
2. Boundary integral option has been added to the analysis code
3. Log-periodic geometry has been added to the list of the geometries that the mesher can tessellate.
4. Non-planar sunstrate option has been added where the layers are decribed by families of linear segments
5. Compressed-row-storage has been implemented in the BI version for memory savings
6. Dimension allocation problem has been reduced to minimum (i.e., specifying surface triangles, edges and nodes before running the mesher. Rest is taken care of by the code itself)
7. Improved MatLab interface

For the rest, the previous manual holds true.

Running FEMA-PRISM:

<u>Mesher:</u>

1. Adjust the dimension parameters "NdmTri", "NdmSEd", and "NdmSNo" in the file called "fema.dm1".
2. Compile the mesher "Mesh.f"
3. Create the input file "MeshIn".
4. Run the mesher
5. use the MatLab interface to view the mesh, identify feed locations, ..etc.

<u>Code:</u>

1. Create the input file "MainIn" for the code.
2. Compile "dm.f"
3. Run "dm.f" (reads in the mesh data already created and creates a decent fema.dm1" file).
4. Compile "FEMA-PRISM.f"
5. Run the code for memory allocation (see the description of "MainIn")
6. Compile "FEMA-PRISM.f" again
7. Run the code for analysis.

Currently only BI option is working.

MainIn

- I → 1 = Boundary Integral termination, 2 = Artificial Absorber termination
- I → 1 = Adaptive frequency sweep, 2 = Uniform frequency sweep
- R → Desired amount of increment in the input impedance (in Ohms) — *present if the previous line has the entry "1".*
- I I
  - → 1 = Printed, 0 = Slot,
  - → 1 = Compute memory allocation, 0 = Analysis
- I I I I
  - → # of substrate layers
  - → 1 = all substrate layers are identical and planar, 0 = non-uniform but planar, 2 = Non-uniform and non-planar
  - → # of superstrate layers (enter zero for no superstrate)
  - → 1 = all superstrate layers have the same thickness and material parameters, 0 = otherwise

for planar substrate:

- R C C
- R C C
- : : :
- R C C

} Ordered from the bottom of the cavity up, each row corresponds to a substrate layer. Only one row is needed if all layers are identical (row has the info for a single layer).

  - → Thickness of the layer
  - → Relative permittivity of the layer
  - → Relative permeability of the layer

for non-planar substrate. Works with BI option only.

- I C C
  - → Number of linear segments
  - → Relative permittivity of the layer
  - → Relative permeability of the layer
- R R R R ......R R

  z- r coordinates of the segments (number of pairs is one more than the frist entry on the previous line)
- I C C
- R R R R ......R R
- :
- I C C
- R R R R ......R R

Ordered from bottom up (forst entry for the bottom ground plane. No entry for the aperture, which is always planar)

present only if there is superstrate and works with the AA option only:

- R C C
- R C C
- : : :
- R C C

} Same as above but for the superstrate. Ordered from the antenna surface up (first row corresponds to the layer just above the antenna surface).

- I → # of probe feeds
- I I I C
- I I I C
- : : :
- I I I C

} Each row corresponds to a probe feed

  - → Surface node number #1
  - → Surface node number #2

  } Probe current flows from node #1 to node #2.
  - → Layer # (layer within which the normally oriented probe is located, or the layer at top of which the laterally oriented probe is located). Entry can be positive or negative and increase away from the surface of the antenna with zero corresponding to the layer immediately below the antenna.
  - → Complex amplitude of the probe current
- R R R I R I I I
  - → Starting frequency in GHz
  - → Final frequency in GHz
  - → Increment frequency in GHz
  - → Frequency run to save (1 = save the first freq. run, 2 = next frequency, etc.)
  - → Tolerance (~ 0.01)
  - → 1 = monitor convergence (dump residual error at each iter.), 0 = otherwise
  - → 1 = compute element matrices assuming distorted prism (must for doubly-cureved or non-planar substrates), 0 = read in element matrices, 2 = compute assuming right prism (excellent for BI case)
  - → Maximum number of iterations
- I → 1 = Read in user specified termination parameters (given in the following row), 0 = code will figure out the optimum parameters (this is the safe course if one is not familiar with the artificial absorber termination).
- R I I C
  - → Thickness of one layer (all layers have the same thickness)
  - → Total number of layers from the top of the outer-most superstrate layer to the termination boundary
  - → Number of absorber layers
  - → Relative permittivity of the absorbing layers. — *Unity for BI*

Mesh.f

Three types of configurations: 1) Log-periodic
2) Circular
3) Rectangular

The antenna could be printed or slot

Reads in input file "MeshIn" which contains geometry info and creates the following files:

SurfMesh ⟶ For FEMA-PRISM
MeshDs
Attr
AngInt
AntEdg ⟶ For mesh display on MatLab
CavEdg
SrfEdg
Setup.m

Before running "Mesh.f", one must have two files in the same directory:

Plot.aux Contains the statement "axis('equal') in its first line.
fema.dm1 Contains the parameter statement for memory allocation. An example is given belov

```
    PARAMETER(NdmPri= 12321,NdmTri=  3081,NdmSEd=  4713,NdmSNo=  1634,
   &NdmVEd= 30093,NdmVNo=  8166,NdmNZE= 19629,NdmLay=    5,
   &NdmRow=  243569,NdmNZS=  249)
```

This statement is also used by the FEMA-PRISM code, and for the mesher, only three parameter are needed to be specified:

NdmTri: Maximum number of triangles expected in the final mesh
NdmSEd: Maximum number of edges "
NdmSNo: Maximum number of nodes "

The file "Mesh.f" must be compiled after the dimension allocations are specified.

MeshIn - 1

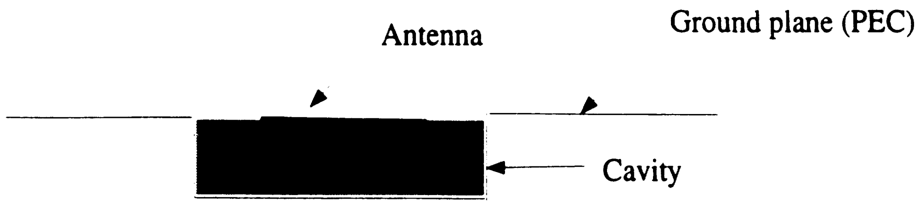
Line #1: I I I

- 1 = Boundary Integral (BI), 0 = Artificial Absorber (AA)
- 1 = Log-periodic, 2 = Circular, 3 = Rectangular
- 1 = Printed, 0 = Slot

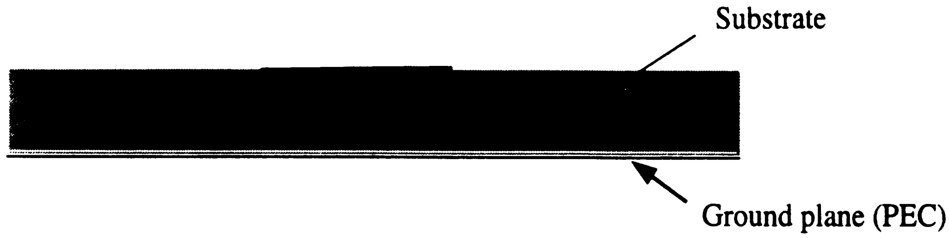
R: Real
I : Integer

Lines #2-4 depend on the entries on Line #1 (see the following pages).

Cavity-backed:

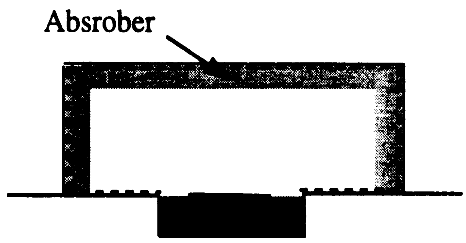
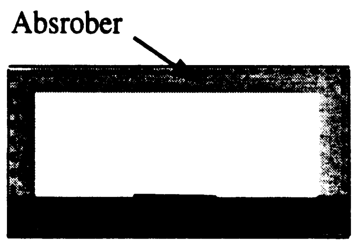


Microstrip:



Modeling of the above two configurations with Bi and AA terminations:

(Computation space is circled with dashed lines)

Termination Technique / Configuration	Boundary Integral (BI)	Artificial Absorber (AA)
Cavity-backed		
Microstrip	Does not apply	

MeshIn - 2

BI termination / Log-periodic - 1 (Only "cavity-backed" configuration is available)

Line #1: 1 1 1 or 1 1 0

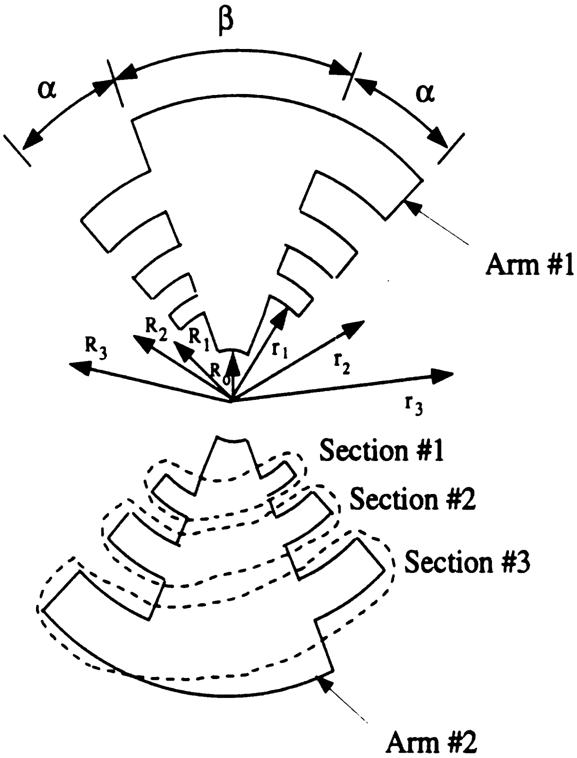
Line #2 : R R I I R R R R R

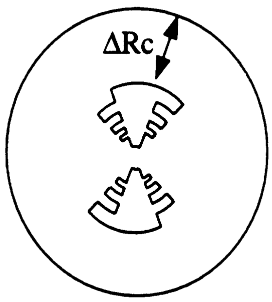
- ► α (deg.)
- ► β (deg.)
- ► Na (# of arms)
- ► Ns (# of sections)
- ► Ro
- ► R1
- ► τ
- ► κ
- ► ΔR (suggested radial discretization length for the mesh)

R: Real
I: Integer

Line #3: R ► ΔRc (distance from the antenna boundary to the cavity wall)

Definition of the parameters





$$\tau = \frac{R1}{R2} = \frac{R2}{R3} = \frac{R3}{R4} = ...$$

$$\kappa = \frac{R1}{r1} = \frac{R2}{r2} = \frac{R3}{r3} = ...$$

Note: $\kappa \sim \sqrt{\tau}$ for equal metal and air teeth width
$\Delta R \leq Ro / 3$ for decent mesh quality around the center of the antenna

MeshIn - 3

BI termination / Log-periodic - 2

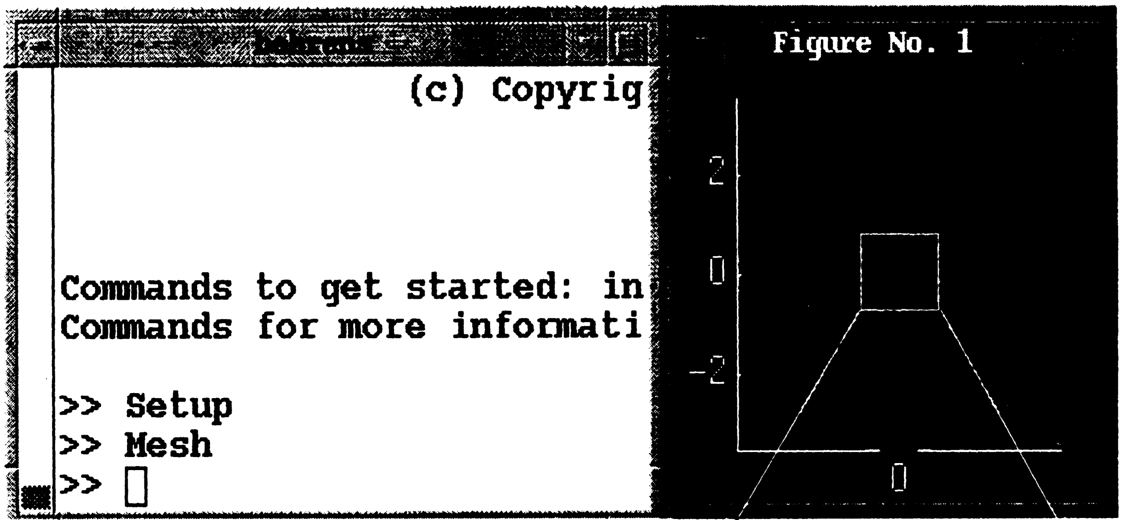
Example run - 1

Line #1:	1	1	1						
Line #2:	45	35	2	2	.66	1.	.6	.775	.22
Line #3:	.72								

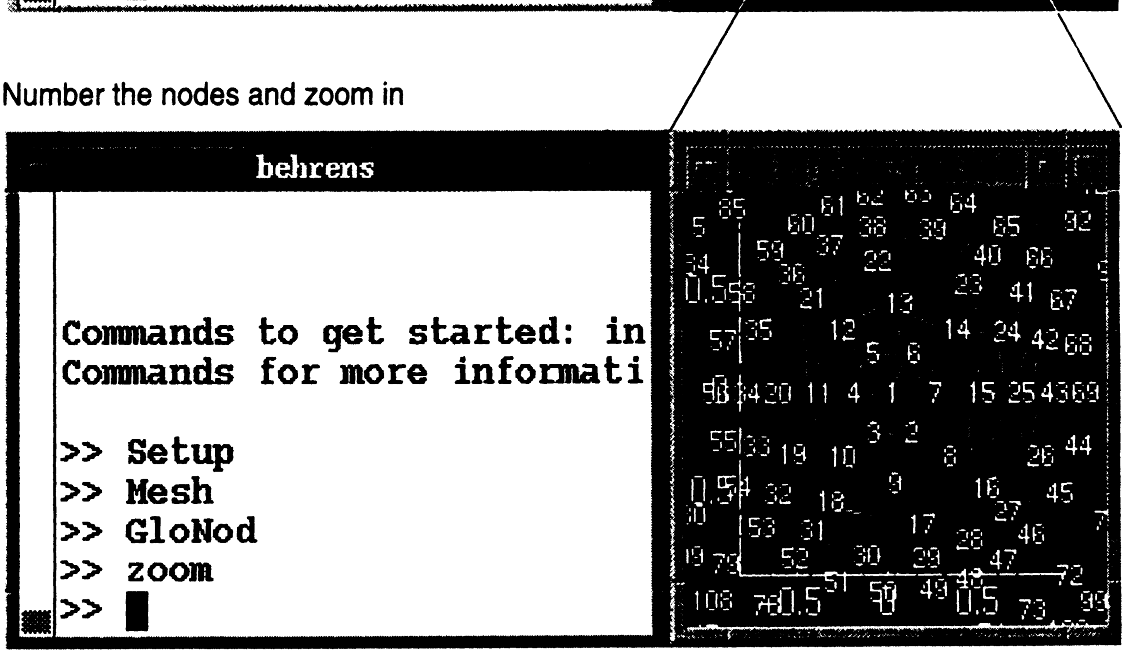
After running the mesher, one can view the mesh, number the nodes and assess the mesh quality using MatLab as shown below:

MATLAB INTERFACE

1. Display the mesh



2. Number the nodes and zoom in



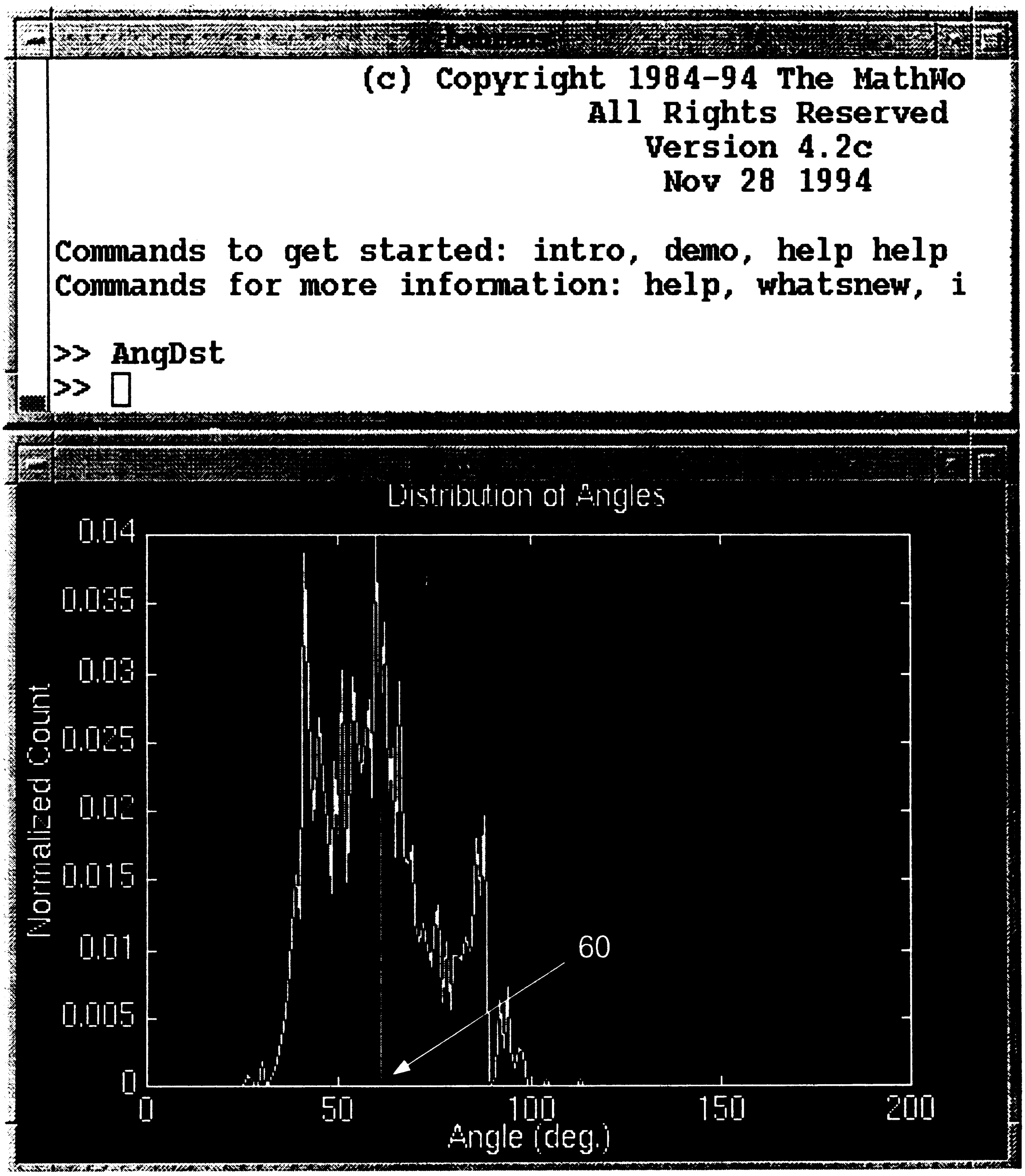
MeshIn - 4

BI termination / Log-periodic - 3

Example run - 2

3. Distribution of internal angles for the mesh just created

This is very useful for assessing the quality of the mesh. The ideal distribution is a delta function located at 60 degrees and represents a ferfect surface mesh. The more concentrated the distribution is around 60 degrees the better. One can conclude that the mesh created is a decent one. In fact, same behavior should be expected each time one uses the mesher to tessellate a log-periodic geometry.



MeshIn - 5

BI termination / Circular - 1 (Only "cavity-backed" configuration is available)

Line #1: 1 2 1 or 1 2 0

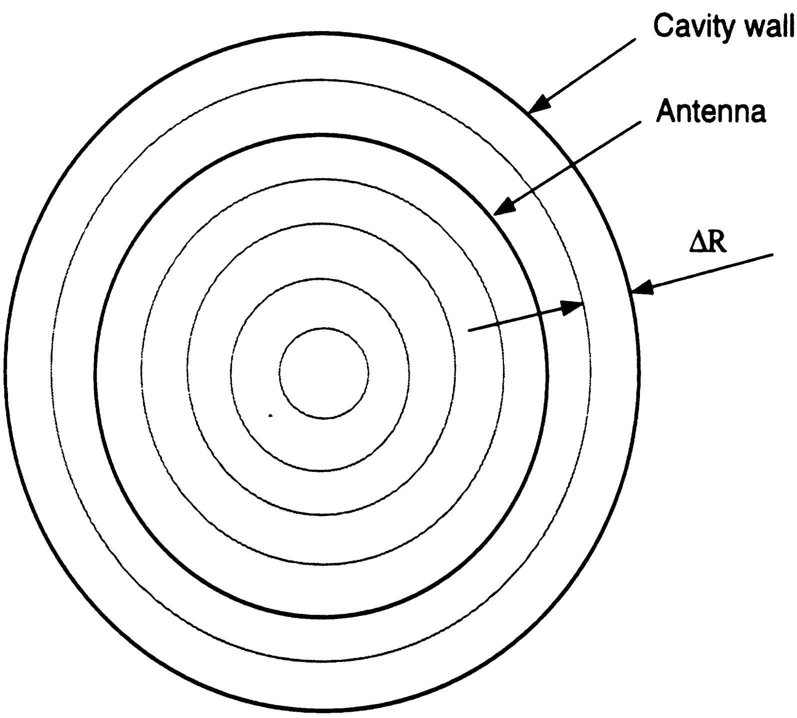
Line #2 : R I

- ► ΔR (radial thickness of the rings)
- ► Na (# of antenna rings)

Line #3: I

- ► Nc (# of rings between the antenna and the cavity wall)

<u>Definition of the parameters</u>



Warning: Nc > 1

For the above example: Na = 5, Nc = 2

MeshIn - 6

BI termination / Circular - 2

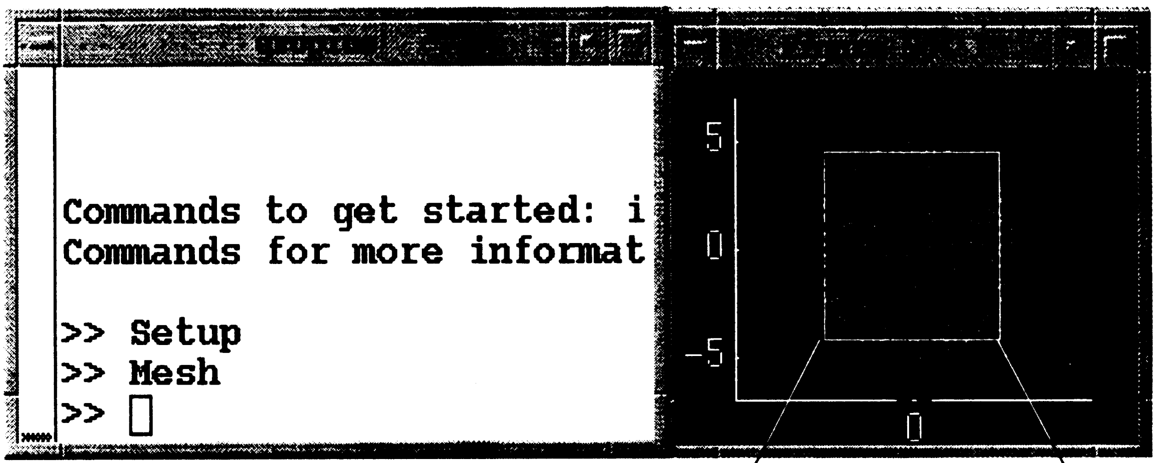
Example run - 1

Line #1:   1 2 0   (slot antenna)
Line #2:   1 5
Line #3:   2

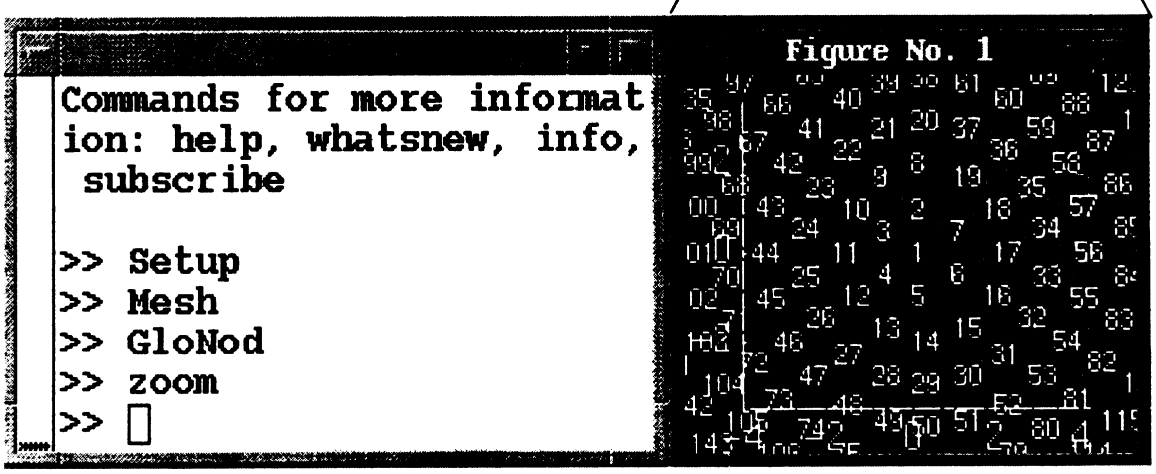
After running the mesher, one can view the mesh, number the nodes and assess the mesh quality using MatLab as shown below:

MATLAB INTERFACE

1. Display the mesh



2. Number the nodes and zoom in

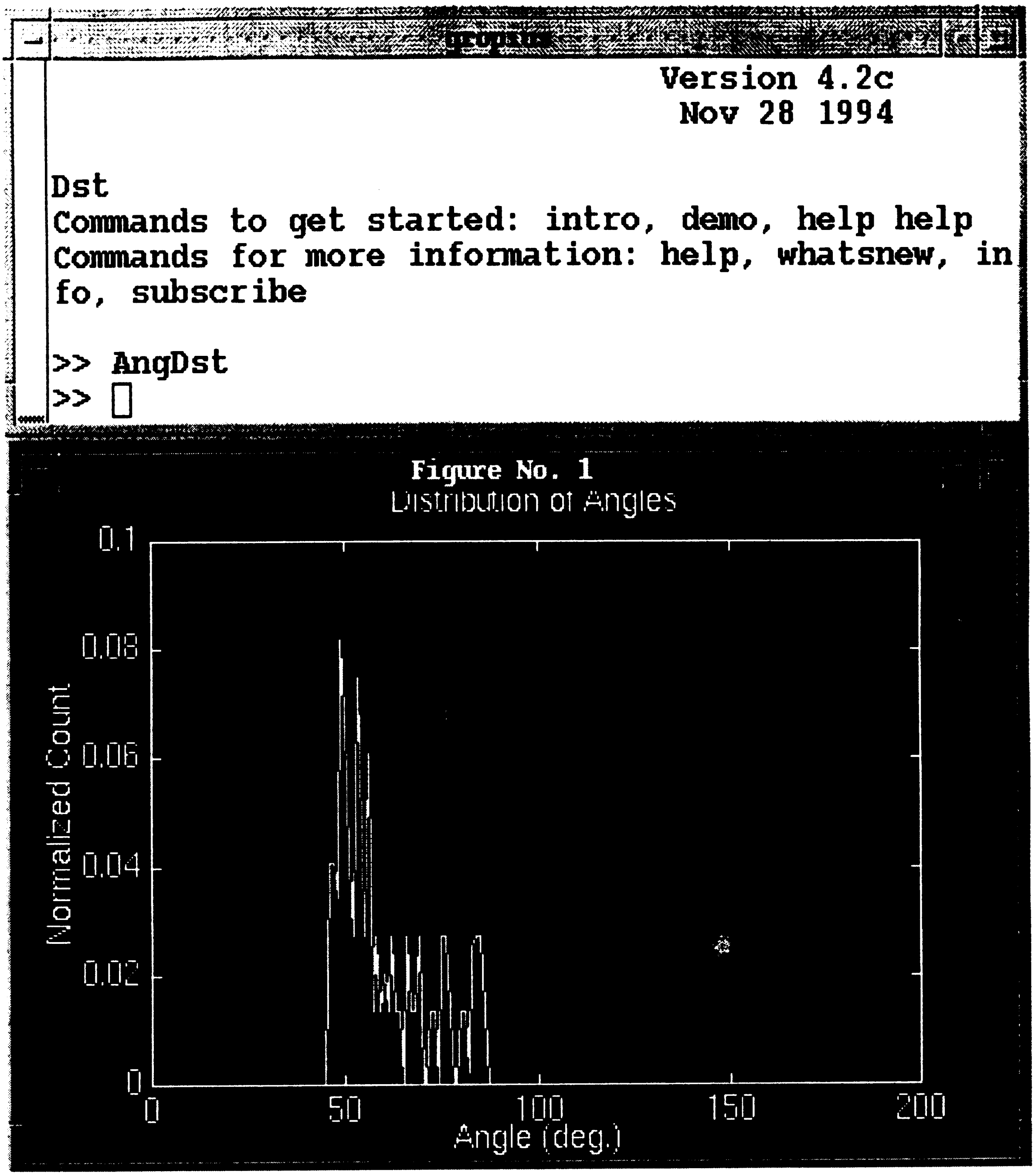


MeshIn - 7

BI termination / Circular - 3

Example run - 2

3. Distribution of internal angles for the mesh just created



MeshIn - 8

BI termination / Rectangular - 1

Line #1: 1 3 1 or 1 3 0

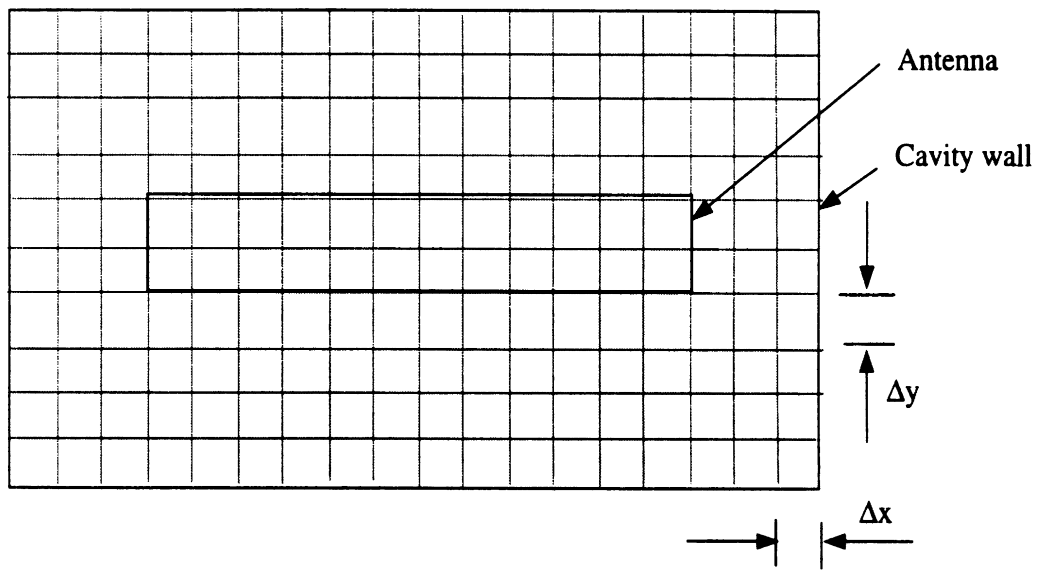
Line #2 : R R I I

- ► Δx (sampling cell size in x-direction)
- ► Δy (sampling cell size in y-direction)
- ► NxA (number of antenna cells in x-direction)
- ► NyA (number of antenna cells in y-direction)

Line #3: I I

- ► NxC (# of cells between the antenna and the cavity wall in x-direction)
- ► NyC (# of cells between the antenna and the cavity wall in y-direction)

<u>Definition of the parameters</u>



For the above example: NxA = 12, NyA = 2, NxC = 3, NyC= 4

Warning: NxC, NyC > 2

MeshIn - 9

BI termination / Rectangular - 2

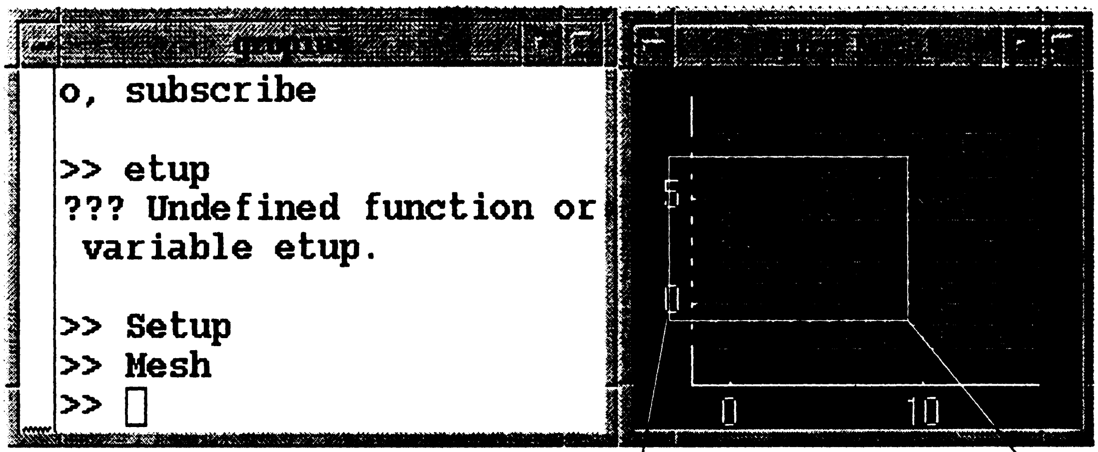
Example run - 1

Line #1: 1 3 1 (printed)
Line #2: 1 1 12 2
Line #3: 3 4

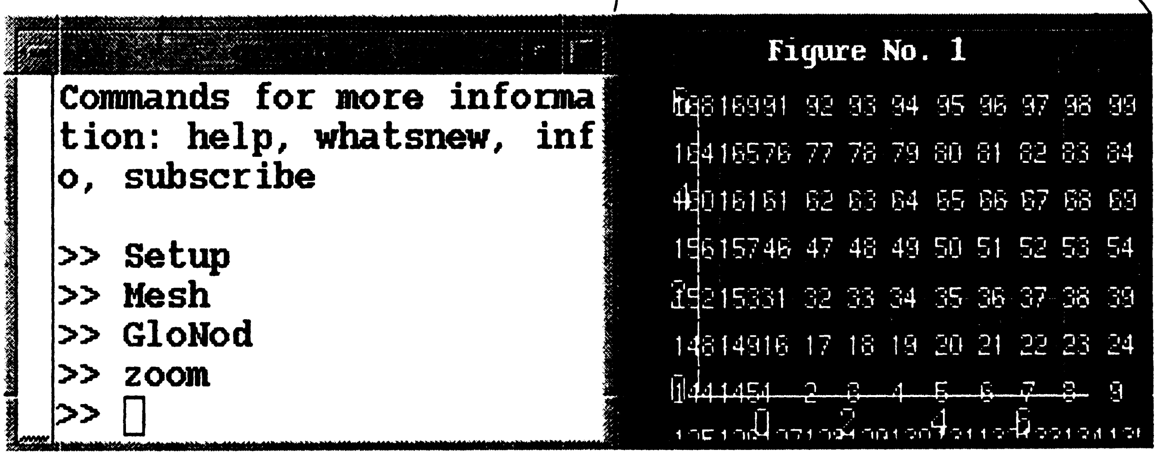
After running the mesher, one can view the mesh, number the nodes and assess the mesh quality using MatLab as shown below:

MATLAB INTERFACE

1. Display the mesh



2. Number the nodes and zoom in

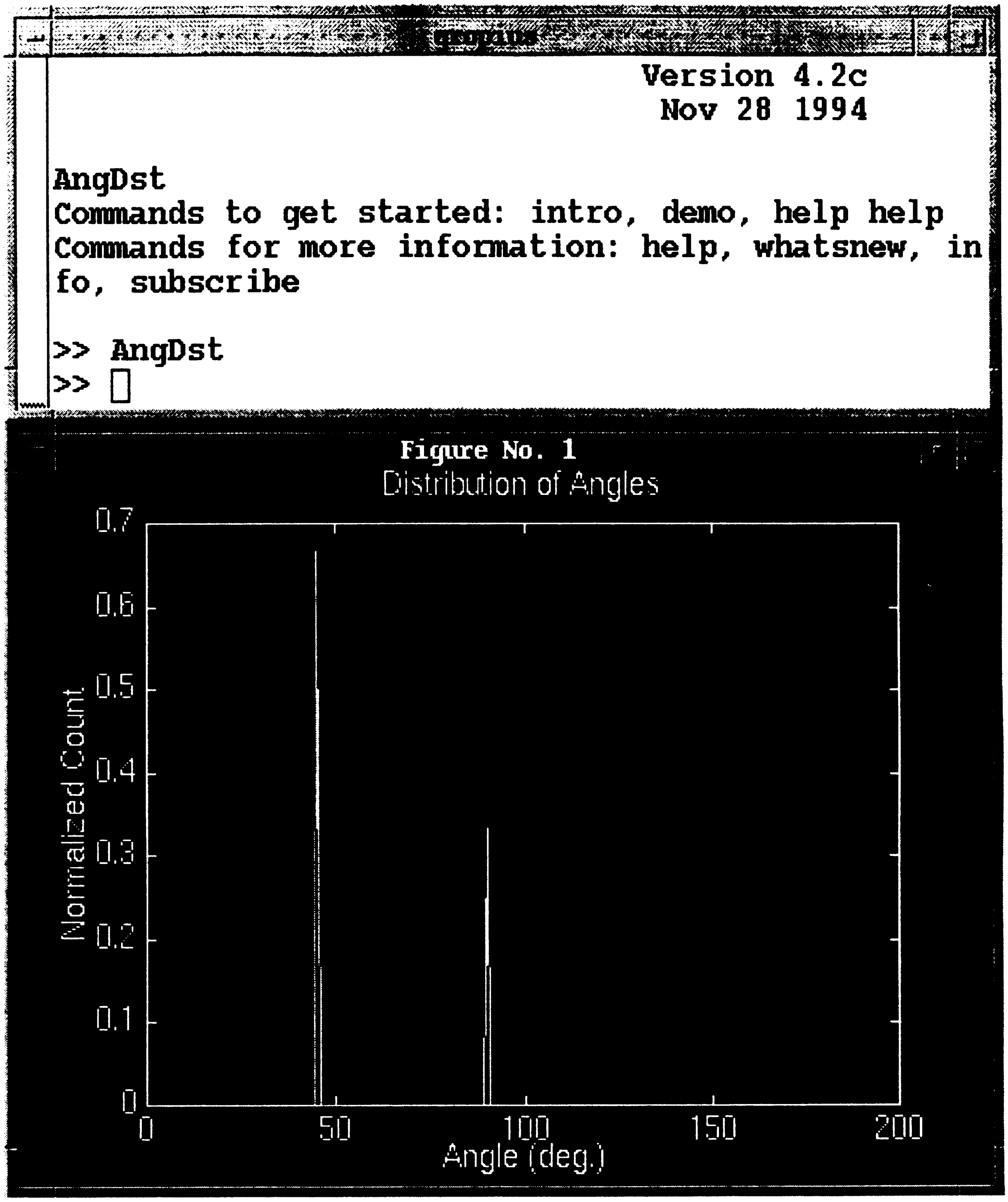


MeshIn - 10

BI termination / Rectangular - 3

Example run - 2

3. Distribution of internal angles for the mesh just created



MeshIn - 11

AA termination / Log-periodic

Line #1: 0 1 1 or 0 1 0 (printed or slot)

Line #2 : R R I I R R R R R

- α (deg.)
- β (deg.)
- Na (# of arms)
- Ns (# of sections)
- Ro
- R1
- τ
- κ
- ΔR (suggested radial discretization length for the mesh)

Line #3: I

- 1 = Cavity-backed, 0 = Microstrip

Line #4: R R R — cavity-backed

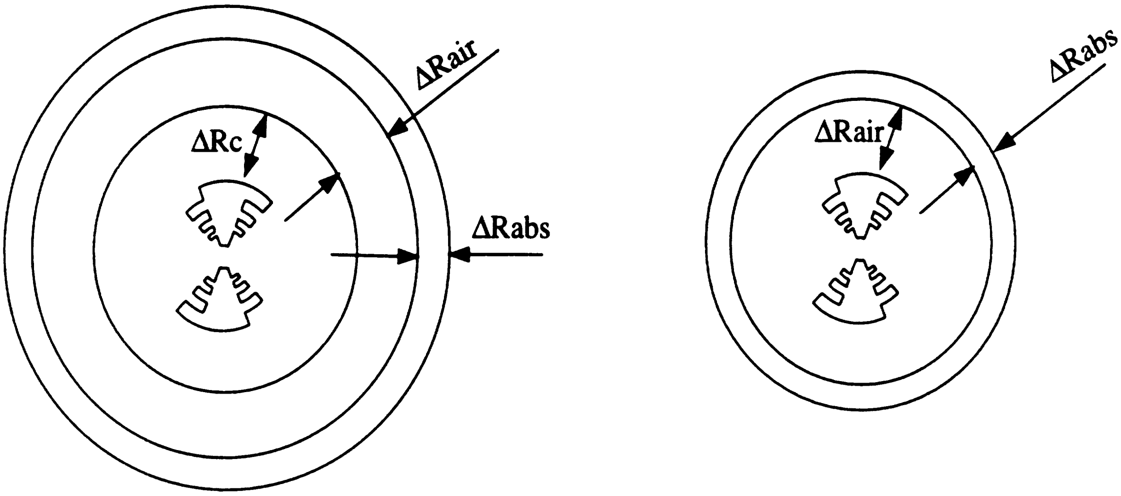
- ΔRc (distance from the antenna boundary to the cavity wall)
- $\Delta Rair$ (thickness of the air gap)
- $\Delta Rabs$ (thickness of the absorber)

Line #4: R R — microstrip

- $\Delta Rair$ (thickness of the air gap)
- $\Delta Rabs$ (thickness of the absorber)

Definition of the parameters

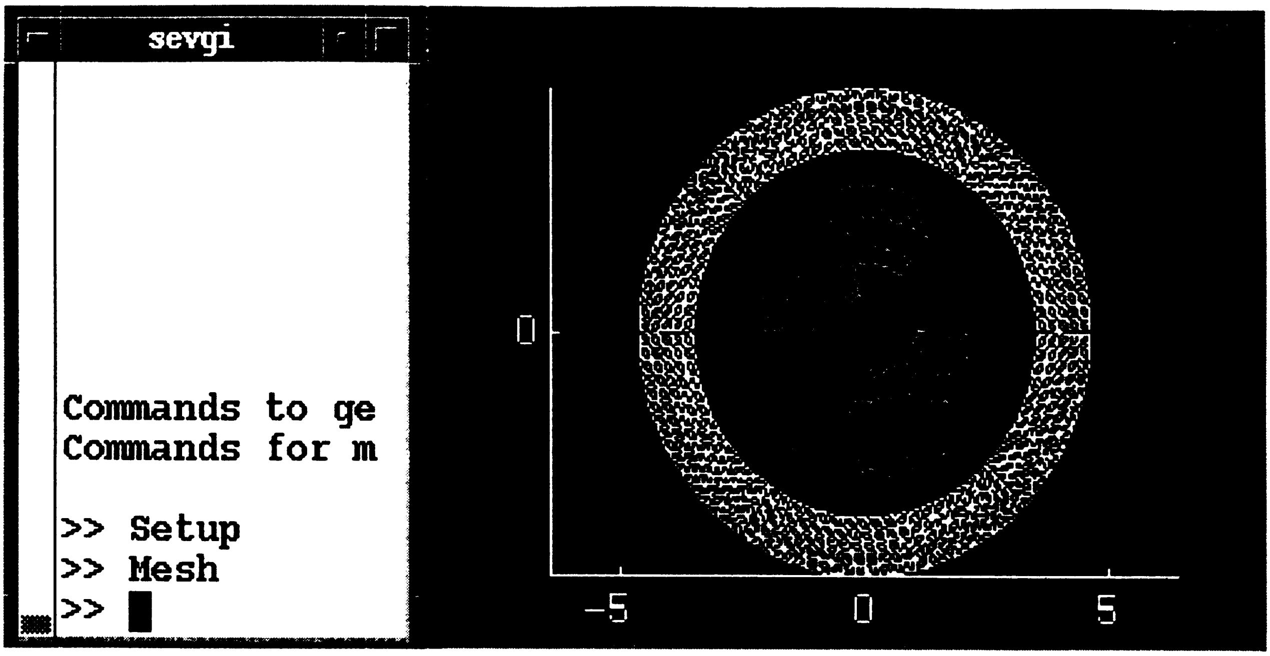
Definitions of Line #2 parameters are the same as before



cavity-backed microstrip

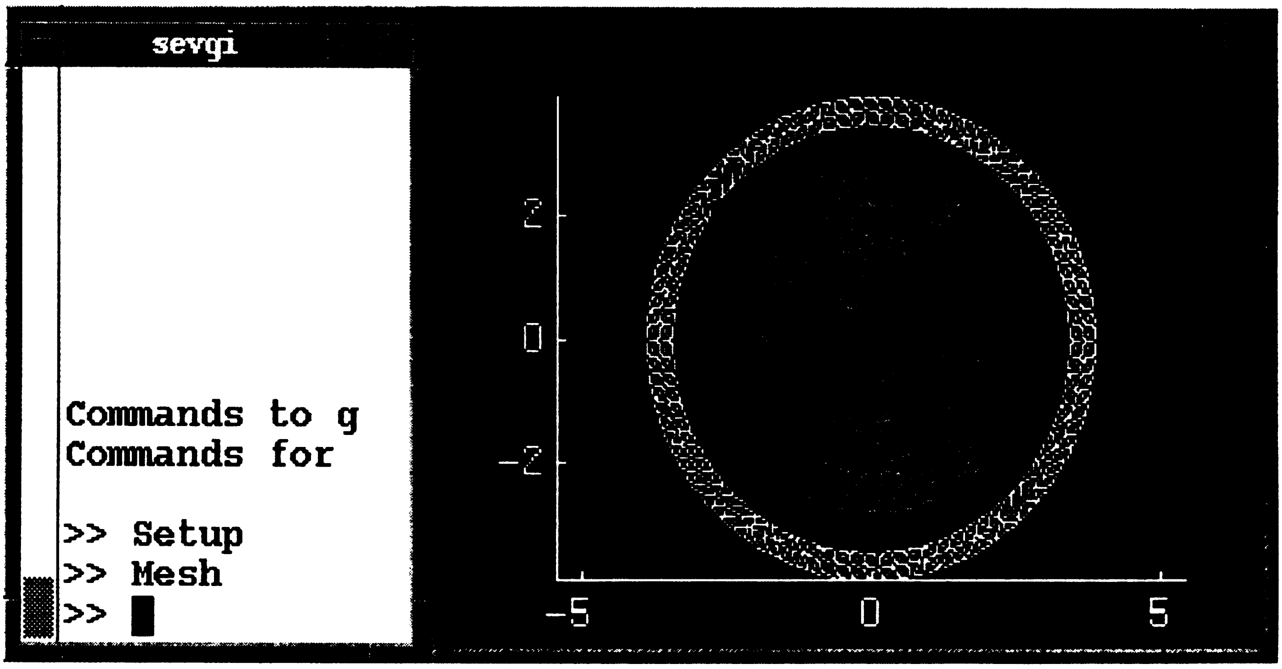
AA termination / Log-periodic / Cavity-backed

Line #1: 0 1 0 (slot antenna)
Line #2: 45 35 2 2 0.66 1. 0.6 0.775 0.22
Line #3: 1
Line #4: 0.72 0.66 0.44



AA termination / Log-periodic / Microstrip

Line #1: 0 1 0 (slot antenna)
Line #2: 45 35 2 2 0.66 1. 0.6 0.775 0.22
Line #3: 0
Line #4: 0.66 0.44



MeshIn - 13

AA termination / Circular

Line #1: 0 2 1 or 0 2 0 (printed or slot)

Line #2 : R I

- ► ΔR (radial thickness of the rings)
- ► Na (# of antenna rings)

Line #3: I ► 1 = Cavity-backed, 0 = Microstrip

Line #4: I I I

- ► Nc (# of rings between the antenna and the cavity wall)
- ► Nair (# of air gap rings)
- ► Nabs (# of absorber rings)

cavity-backed

Line #4: I I

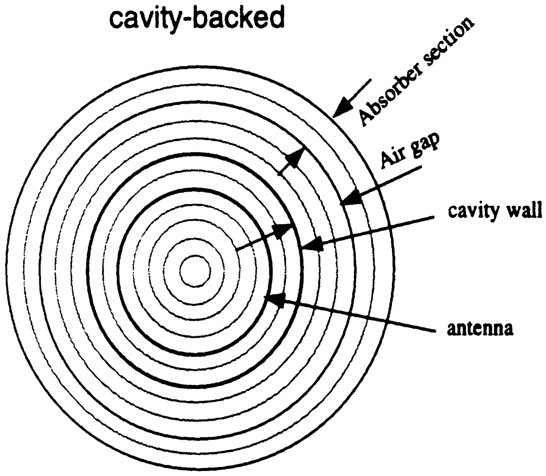
- ► Nair (# of air gap rings)
- ► Nabs (# of absorber rings)

microstrip

<u>Definition of the parameters</u>

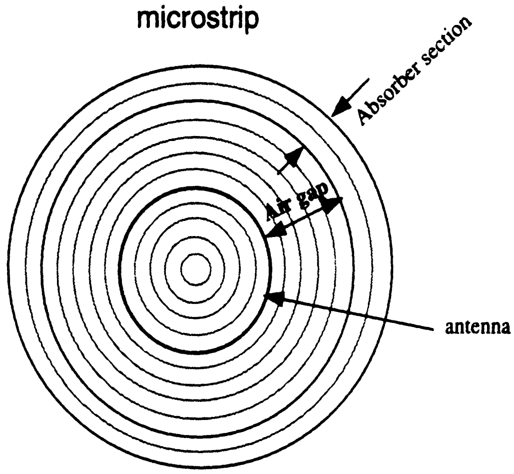
Line #2 parameters have the same definitions as before.

cavity-backed



For the above example:
Na = 5, Nc = 2, Nair = 3, Nabs = 2

microstrip

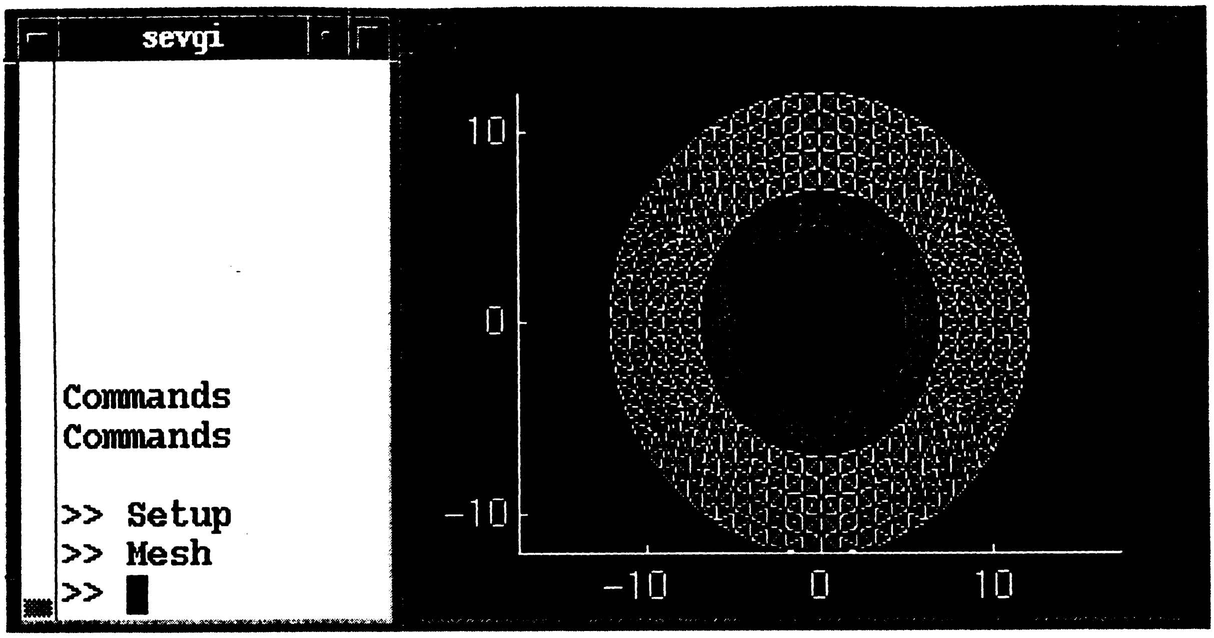


For the above example:
Na = 5, Nair = 5, Nabs = 2

Warning: Nair > 1

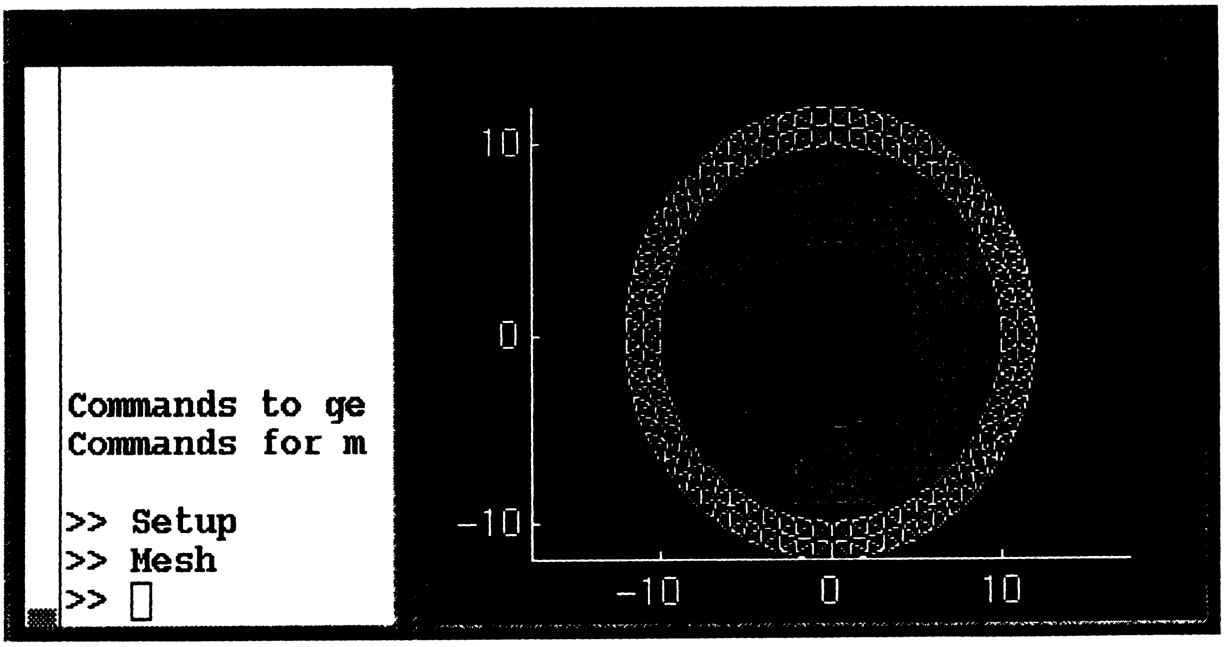
AA termination / Circular / Cavity-backed

Line #1: 0 2 1 (printed)
Line #2 : 1 5
Line #3: 1
Line #4: 2 3 2



AA termination / Circular / Microstrip

Line #1: 0 2 1 (printed)
Line #2 : 1 5
Line #3: 0
Line #4: 5 2



MeshIn - 15

AA termination / Rectangular

Line #1: 0 3 1 or 0 3 0 (printed or slot)

Line #2 : R R I I

- ► Δx (sampling cell size in x-direction)
- ► Δy (sampling cell size in y-direction)
- ► NxA (number of antenna cells in x-direction)
- ► NyA (number of antenna cells in y-direction)

Line #3: I

- ► 1 = cavity-backed, 0 = microstrip

cavity-backed:

Line #4: I I I I I I

- ► NxC (# of cells between the antenna and the cavity wall in x-direction)
- ► NyC (# of cells between the antenna and the cavity wall in y-direction)
- ► NxAir (# of air gap cells in x-direction)
- ► NyAir (# of air gap cells in y-direction)
- ► NxAbs (# of absorber cells in x-direction)
- ► NyAbs (# of absorber cells in y-direction)

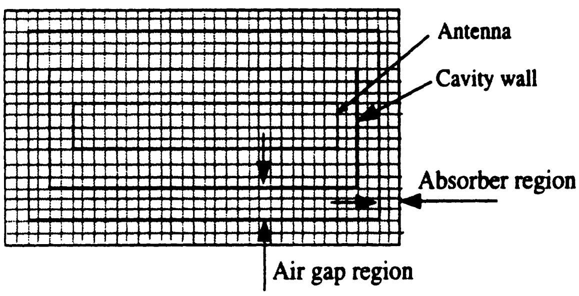
microstrip:

Line #4: I I I I

- ► NxAir (# of air gap cells in x-direction)
- ► NyAir (# of air gap cells in y-direction)
- ► NxAbs (# of absorber cells in x-direction)
- ► NyAbs (# of absorber cells in y-direction)

<u>Definition of the parameters</u>

cavity-backed

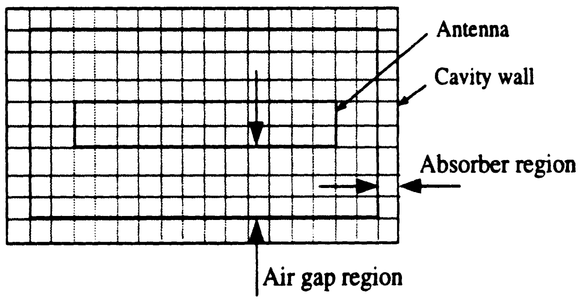


For the above example:

NxA = 24, NyA = 4,
NxC = 2, NyC = 3,
NxAir = 2, NyAir= 3,
NxAbs = 2, NyAbs = 2

Warning: NxAir, NyAir > 0

mircrostrip



For the above example:

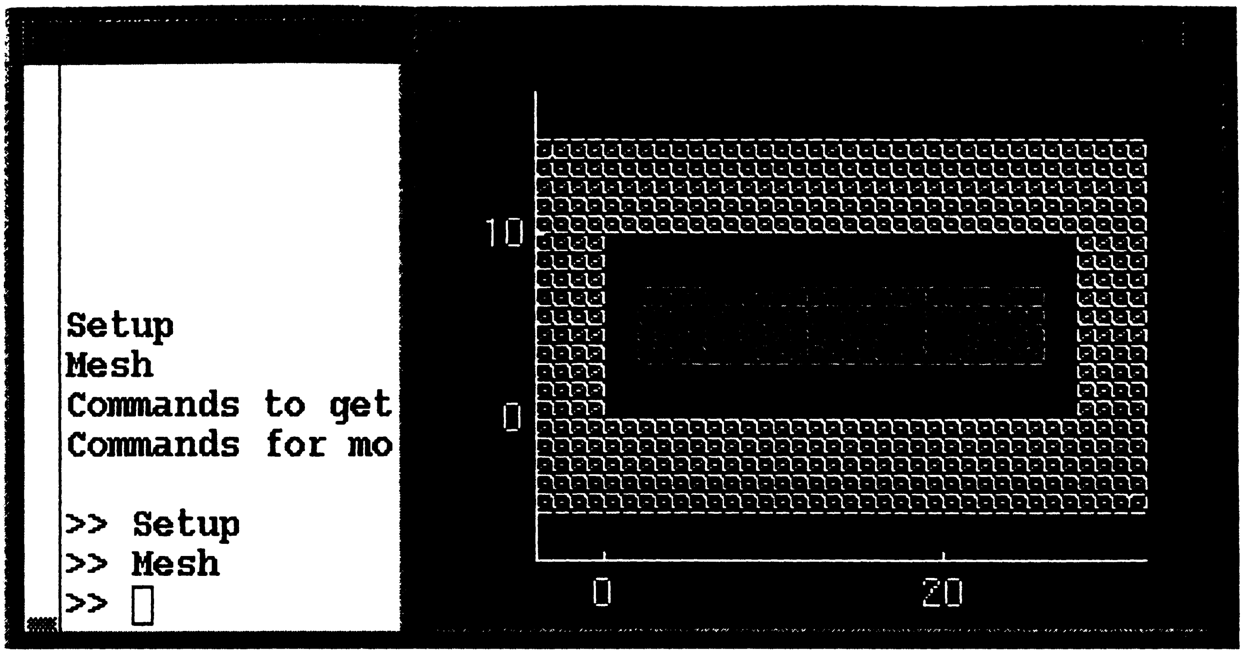
NxA = 12, NyA = 2,
NxAir = 2, NyAir= 3,
NxAbs = 1, NyAbs = 1

Warning: NxAir, NyAir > 1

MeshIn - 16

AA termination / Rectangular / Cavity-backed

Line #1: 0 3 0 (slot)
Line #2: 1 1 24 4
Line #3: 1
Line #4: 2 3 2 3 2 2



AA termination / Rectangular / microstrip

Line #1: 0 3 0 (slot)
Line #2: 1 1 12 2
Line #3: 0
Line #4: 2 3 1 1