NEC Plotting Programs

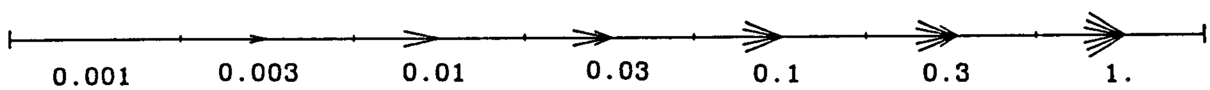
NECPLOT

PATPLOT

ZPLOT

Program NECPLT

NECPLT is a program to plot an isometric view of a wire structure from a NEC input or output file. With input data files it can be used to check for errors in the wire model. With output files the real or imaginary part of current can be displayed as arrows. The arrow size is proportional to the log of normalized current as shown below:



A sample command listing, obtained on line with the SH command, follows:

```
COMMANDS - -
VA thet,phi,eta: VIEWING ANGLES              ZX f: ZOOM BY FACTOR f
SC i: CENTER ON SEGMENT i                    DV: SET GRAPHICS DEVICE
PT: DISPLAY PLOT ON TERMINAL                 SE: MARK SEGMENT ENDS
PL: SEND PLOT TO LASER PRINTER               FE: SHOW FREE ENDS
NF: READ NEW INPUT FILE                      EX: EXIT
RF: CONTINUE READING INPUT FILE              SH: SHOW COMMANDS
AR: DISPLAY ARROWS FOR REAL PART OF CURRENT
AI: DISPLAY ARROWS FOR IMAGINARY PART OF CURRENT

VA:      45.000     45.000      0.000
SC:      0          ZX:      1.00
CURRENT ARROWS: REAL
CURRENT NORMALIZATION FACTOR =  1.23400E-03

FILE: input file name
NUMBER OF SEGMENTS =     20
FREQUENCY =  5.00000E+00 MHZ
```

****

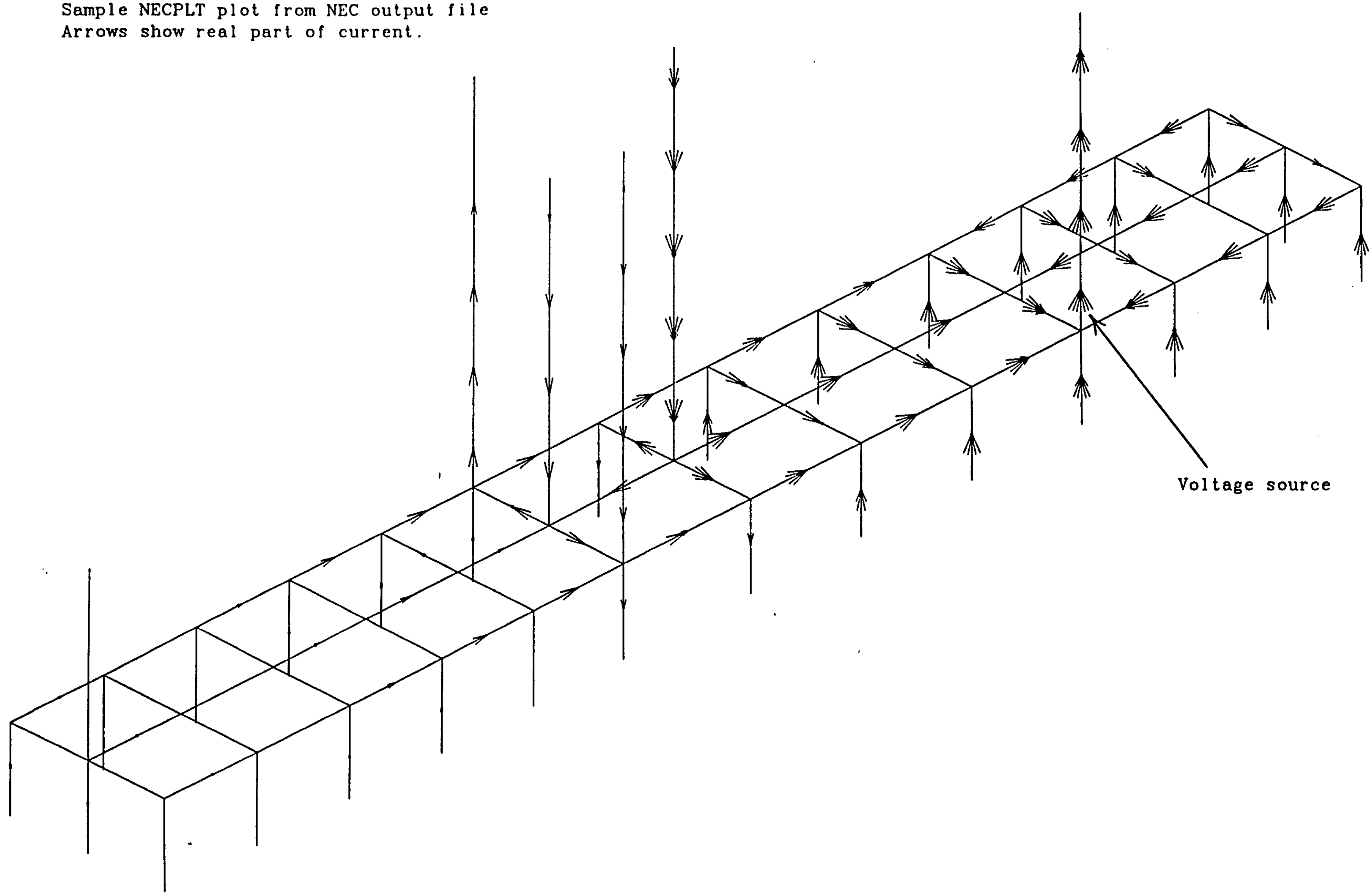
There is an additional command not shown in the above display:

SP r1,r2

which scales the plot (and arrows) by r1 and scales the arrows only by r2. This is useful to keep the arrows from overlapping on a model with many segments. It also can be used to produce a reduced size plot with extra large arrows to show up in a report.

The AR, AI, SE and FE commands can be canceled by entering the command followed by a nonzero value. For example, SE1 canceles a SE command.

Sample NECPLT plot from NEC output file
Arrows show real part of current.



PLOT 1

Program PATPLOT2 for Windows

PATPLOT2 is a program to read NEC output files and plot radiation patterns. For each pattern that it finds, the gain is displayed on a 2D polar or Cartesian plot. When a 3D pattern is found (more than one value of θ and ϕ) it offers the option to plot the 3D pattern. This is an enhanced version of the program PATPLOT that has been distributed with NEC, and would only plot polar patterns. The 3D plotting uses the subroutines developed by Dr. Waymond Scott Jr. at Georgia Tech. [1]. These programs have been modified to interface with the DIGLIB graphics library [2] which includes basic plotting routines with versions for Windows, UNIX, Macintosh and DEC/VMS operating systems.

PATPLOT2 operates in two modes with different sets of commands for 2D and 3D plots. It starts in 2D mode and reads and plots patterns until it finds a complete 3D pattern. Then it asks if the user wants to plot the 3D pattern. Each plot is displayed on the screen. It can be printed on a Postscript printer with the PL command. However, in the Windows and Macintosh versions it just writes the Postscript file on the disk in the directory in which the input file was opened. The user must use the operating system commands to send the file to a Postscript printer to be rendered.

2D mode

PATPLOT2 starts in 2D mode and plots each pattern as it is read. It checks whether the θ or ϕ angle is changing and shows the changing angle and fixed angle on the plot. The θ (vertical) component of gain is plotted as a solid line and the ϕ (horizontal) component as a dashed line. The default puts the zero angle at the top of the plot with the angle increasing clockwise, but this can be changed with input commands. The 2D plot also shows the frequency, input impedance and efficiency read from the file. The following commands are accepted by PATPLOT2 in 2D mode:

2D Commands:

<return>	– Read and plot the next 2D pattern
RD	– Read the remainder of a 3D pattern block without plotting. Then ask if a 3D plot is wanted. If a single θ or ϕ cut is found it will plot the 2D pattern.
RF	– Skip out of a 3D pattern table to search for the next pattern table
RW	– Rewind the file and start at the beginning
CP	– Show 2D patterns on Cartesian plots
PP	– Show 2D patterns on polar plots (default)
ST	– Store the currently displayed 2D pattern to overlay on other plots
RC	– Recall a stored 2D pattern to overlay on other plots
RX	– Turn off the stored pattern overlay
EX	– Exit from the program
NF	– Open a new NEC output file
RB	– Reverse the screen background black to white (toggels)
PL	– Write a Postscript file for a printer
PH	– Write a file of HPGL graphics commands for Hewlett Packard plotters
PT	– Redraw the plot on the screen
RM	– Put zero at the right of the plot with positive angles plotted clockwise
RP	– Put zero at the right of the plot with positive angles plotted counterclockwise

UP – Put zero at the top of the plot with positive angles plotted counterclockwise
UM – Put zero at the top of the plot with positive angles plotted clockwise (default)

3D mode

When PATPLOT2 gets to the end of a 3D pattern table (two or more values of θ and ϕ) it displays a message asking if a 3D plot is wanted. The default is to make the 3D plot, and "n" must be entered to continue in 2D mode. When in 3D mode, the command 2D can be used to return to 2D mode and continue reading the NEC file.

The time to generate a 3D plot will depend on the number of angles in the pattern. In many cases, five degree increments in θ and ϕ (73×37 points for a sphere) will give a good rendering of the 3D pattern and will plot with little time delay. With two degree increments in θ and ϕ covering the sphere (181×91 points) plotting will take several seconds on a 200 MHz Pentium system, and the NEC output file will be fairly large (around 2 MB). The program is dimensioned for a maximum of 361×181 values in θ and ϕ, but it is usually not necessary to use such small increments. If the range of ϕ is less than 360 degrees, the exposed interior of the pattern will appear blank without lines. This can sometimes be useful to show the pattern shape on the exposed edge, as shown in [1]. If the range of θ angles is less than 180 degrees, lines will be drawn on the exposed interior.

On Windows systems the 3D plot on the screen is colored by phase for vertical and horizontal gain and by axial ratio for total gain. The frequency, maximum gain and angles for maximum gain are also shown. Commands in 3D mode are:

3D Commands:

VA θ ϕ – Set the viewing angles to θ, ϕ degrees
GV – Plot vertical gain on a dB scale (default)
GH – Plot horizontal gain on a dB scale
GT – Plot total gain on a dB scale
LV – Plot vertical gain on a linear scale
LH – Plot vertical gain on a linear scale
LT – Plot vertical gain on a linear scale
GR f_1 – set the plot range (origin to the peak) to f_1 dB (default 40 dB)
CP – Turn off color for phase and axial ratio (toggles)
EX – Exit from the program
2D – Return to 2D plotting mode to continue reading the file
RB – Reverse the screen background black to white (toggels)
PL – Write a Postscript file for a printer
PH – Write a file of HPGL graphics commands for Hewlett Packard plotters
PT – Redraw the plot on the screen

References

[1] W. Scott Jr., "A General Program for Plotting Three-Dimensional Antenna Patterns," IEEE Antennas and Propagation Society Newsletter, Vol. 31, No. 6, pp. 6-11, December 1989.

[2] H. Brand, "DIGLIB — Divice Indepentent Graphics Library," *CAE Tools and Systems Newsletter*, Lawrence Livermore National Lab. Jan. 1986.

Program ZPLOT

Program ZPLOT will read NEC output files and plot the antenna input impedance or admittance versus frequency. Data can be displayed in Cartesian plots of impedance or admittance, real or imaginary parts of these quantities or a Smith chart. ZPLOT reads commands from the user's terminal and immediately displays the resulting plot on the screen. The user can then enter a command (PL) to send a displayed plot to a printer. The program is written in Fortran and must be linked with the graphics library DIGLIB [1].

ZPLOT includes capabilities for displaying multiple curves, combining data files and interpolating data. Data points from new files can be added to existing curves, and the combined data will be sorted in order of increasing frequency and plotted. In addition, the frequency samples can be interpolated using rational-function interpolation, or Cauchy's technique [1]. Data read from NEC output files or combinations of files or data generated by interpolation can be written to new files in a format including frequency and admittance or impedance. These files written from ZPLOT will be much smaller than the NEC output files which include a large amount of additional information. The impedance or admittance files written by ZPLOT can also be read by ZPLOT and plotted. The commands accepted by ZPLOT are described below.

Commands:

AD *ic* – Read a new file and add the data to curve *ic*. If *ic* is omitted or out of range a prompt is displayed for a new value. Next, the name of the input file is requested. The file may be a NEC output file or a compressed impedance or admittance file written by ZPLOT. After adding the new data points, all values for the curve are sorted in order of increasing frequency.

CL – Clear all curves and request a new input file.

DV – Change the device type for the terminal display. A table of available DIGLIB device drivers is displayed and a device number requested. The terminal device type can be changed permanently by changing the value assigned to the variable IDEV at the beginning of the program.

ER *ic* – Erase curve number *ic*.

EX – Exit from the program.

FL *f1 f2* – Limit the frequency range for Cartesian plots to the interval *f1* to *f2*.

ID – Display a table identifying the curves. The first line of each entry shows the file name and number of points. If the curve was obtained by interpolating another curve during the present ZPLOT run, the number of points fit and the slide interval are shown. The second line of each entry is the first title line obtained when the original NEC output file was read.

IN *ic np nf ns* – Interpolate a curve using rational-function interpolation to create a new curve, where *ic* is the number of the curve to be interpolated, *np* is the number of points in the interpolated curve, *nf* is the number of points to fit in the sliding interpolation window and *ns* is the slide interval. Default values are *ic*= last curve, *np=200*, *nf=7* and *ns=1*.

NF – Read a file and create a new curve.

PL – Send currently displayed plot to a printer. The DIGLIB device to which the plot is sent with the PL command is set by the variable IDLASR at the beginning of the program.

PT – Redraw the plot on the terminal screen.

PZ *ic* – Display a table of frequency, impedance and normalized impedance for curve *ic*.

RB – Reverse screen background, black to white.

SC – Display a Smith chart plot of normalized impedance.

SH – Display a table of commands accepted by program ZPLOT.

SY *ic ns* – Put symbols on the Smith chart for curve *ic* with an interval of *ns* points between symbols. If *ic* or *ns* are omitted or zero, a prompt will be displayed for values. If a zero is entered in response to the prompt for *ns*, all symbols will be erased.

VC *n* – Set the VSWR circle on the Smith chart to $n : 1$. If n is omitted a prompt will be displayed for a value. The default is $3 : 1$ and $n = 0$ will eliminate the circle.

YC – Display a Cartesian plot of admittance $(G + jB)$ versus frequency.

YI – Display a plot of conductance G.

YR – Display a plot of susceptance B.

YO *ic* – Write a file of admittance versus frequency for curve *ic*. A prompt is displayed for the name of the file.

ZC – Display a Cartesian plot of impedance $(R + jX)$ versus frequency.

ZI – Display a plot of reactance X.

ZR – Display a plot of resistance R.

ZN Z_0 – Set the normalizing factor for impedance on the Smith chart to Z_0.

ZO *ic* – Write a file of impedance versus frequency for curve *ic*. A prompt is displayed for the name of the file.

Rational-Function Interpolation

ZPLOT interpolates the antenna admittance over frequency using rational-function interpolation or Cauchy's technique [2]. The rational function of frequency f has the form

$$H(f) = \frac{\sum_{i=0}^{m} a_i f^i}{1 + \sum_{i=1}^{n} b_i f^i}. \tag{1}$$

The coefficients of the numerator and denominator polynomials are found by matching $H(f)$ to complex admittance values Y_k computed at N_f sample frequencies f_k to obtain the set of equations

$$H(f_k) = \frac{\sum_{i=0}^{m} a_i f_k^i}{1 + \sum_{j=1}^{n} b_j f_k^j} = Y_k, \qquad k = 1, \ldots, N_f \tag{2}$$

where $N_f \geq m + n + 1$. Equation (2) is then written in the form

$$\sum_{i=0}^{m} a_i f_k^i - Y_k \sum_{j=1}^{n} b_j f_k^j = Y_k \qquad k = 1, \ldots, N_f \tag{3}$$

which represents a matrix equation that can be solved for the coefficients a_i and b_i. The orders of the polynomials are chosen so that $m + n + 1 = N_f$, so that there are an equal number of conditions and unknowns. More specifically, $m = [N_f/2]$ and $n = N_f - m - 1$, so that $m = n$ for N_f odd and $m = n + 1$ for N_f even. Other choices of m and n are possible, but approximately equal orders for numerator and denominator have been found to work well.

The rational function fit to the data samples tends to match the poles and zeros in the actual response function, and hence can be a very efficient means of interpolation. It is particularly effective in interpolating narrow resonances, since a single pole and residue can accurately represent a curve that would require a large number of discrete frequency samples. However, when the number of poles and zeros in $H(f)$ exceeds the number in the transfer function in the vicinity of the sample points the set of equations (3) may become ill-conditioned.

The interpolation in ZPLOT operates on a sliding window, so that for N sample points, N_f can have any value from 2 up to N. The value for N_f and the increment by which the window slides can be set in the IN command. The default is $N_f = 7$ and sliding by one interval. Since the samples do not need to be evenly spaced in frequency, the slide interval in frequency may be variable. Generally values of N_f of 5 or 7 have been found to work well. Larger values may be effective if the sample interval is such that the points span more than one resonance. If the sample interval is very small the equations may become ill-conditioned with small values of N_f. Ill-conditioned equations are indicated by a display PIVOT(i)= [*small number*] where i is the row number at which the routine FACTR was forced to use a small pivot element in the LU decomposition. When this message is printed, some of the poles and zeros found may not accurately represent those in the sampled data. However, the interpolation may still be accurate as long as the poles with largest residues are found accurately.

File Formats

ZPLOT can read either a NEC output file or compressed impedance or admittance files. The latter two file types are written by ZPLOT in response to the ZO or YO commands. ZPLOT recognizes the file type by the first line in the file. If a file starts with a 1 in column one, it is assumed to be a NEC output file. ZPLOT reads the file searching for the FREQUENCY heading to get the frequency and the table ANTENNA INPUT PARAMETERS to get the admittance.

The compressed impedance or admittance files must start with ***NEC IMPEDANCE FILE or ***NEC ADMITTANCE FILE, respectively. The second line of the file is read as a title for labeling the plots. The third line is skipped, and can be used as a heading for the columns. The forth and successive lines contain the frequency and impedance or admittance data. The quantities read are either f, Z_{R}, Z_{I}, I_{symbol} for an impedance file or f, Y_{R}, Y_{I}, I_{symbol} for an admittance file, where the subscripts R and I indicate real or imaginary parts. The input format is (9X, 3E12.5, I5). The first nine columns are skipped so that line numbers can be included there. However, the line numbers are not used by the program. The program reads the file, counting data lines, until an end of file is read.

The value I_{symbol} controls the placement of symbols on the Smith chart. A symbol will be drawn for any data point for which I_{symbol} is nonzero. Values of I_{symbol} can be set with the SY command. Alternatively, the impedance or admittance files can be edited to place symbols at selected frequencies. If symbols are not needed, these values can be omitted.

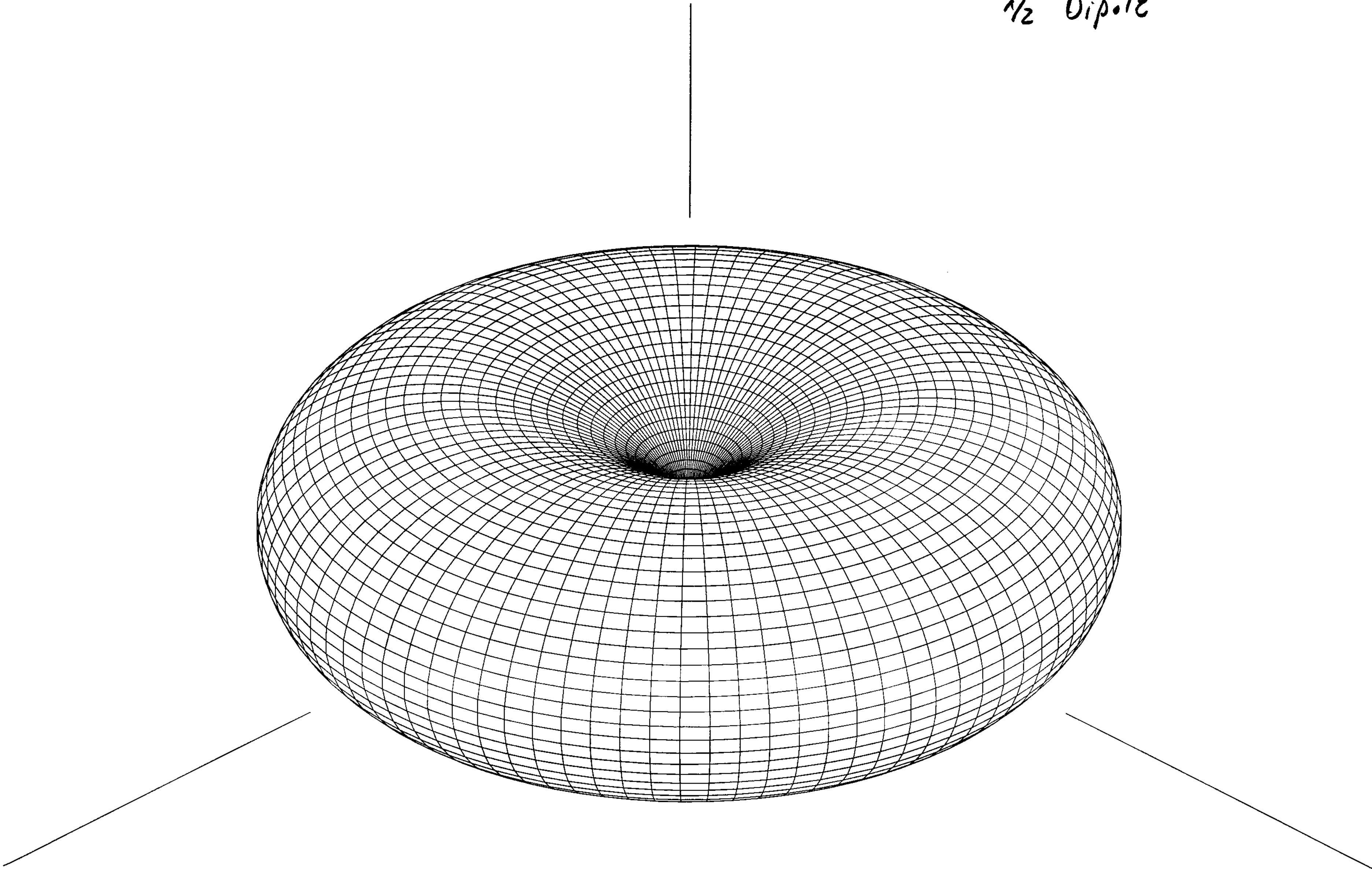
References:

[1] H. R. Brand, *DIGLIB – Device Independent Graphics Library*, Lawrence Livermore National Laboratory, CAE Tools and Systems Newsletter, January 1986.

[2] K. Kottapalli, T. K. Sarkar, Y. Hua, E. K. Miller and G. J. Burke, "Accurate Computation of Wide-Band Response of Electromagnetic Systems Utilizing Narrow-Band Information," *IEEE Trans. Microwave Theory and Techniques*, Vol. 39, No. 4, pp. 682-687, April 1991.

```
CM EXAMPLE #1
CE CENTER FEED HALF-WAVE DIPOLE
GW 1 7 0. 0. -0.25 0. 0. 0.25 0.001
GE
EX 0  1  4  0  1.0  0.0
FR 0  1  0  0  299.8
RP 0  91  91  1000  0.  0.  2.  4.
EN
```

$\lambda/2$ Dipole



F = 3.00E+02 MHz

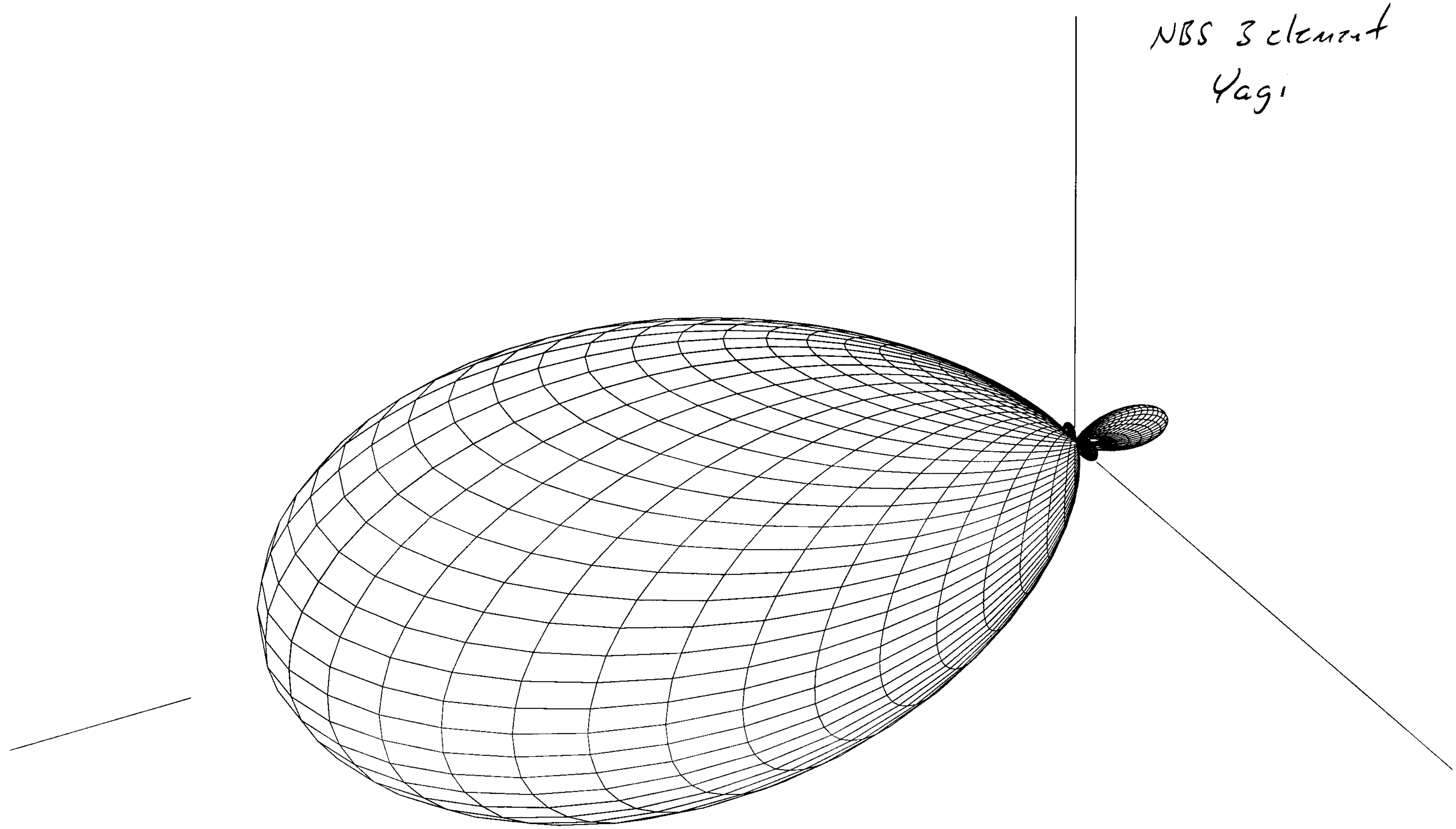
V. Gain: Max = 2.14 dB Linear scale

θmax = 88.0 Ømax = 0.0

view: θ = 60.0 Ø = 45.0

```
CM EXAMPLE #2
CM UDA-YAGI ANTENNA
CE NBS 3 ELEMENT DESIGN
GW 1 7  0.   0. -0.231  0.   0. 0.231 0.00425
GW 2 7 -0.2 0. -0.241 -0.2 0. 0.241 0.00425
GW 3 7  0.2 0. -0.221  0.2 0. 0.221 0.00425
GE
EX 0  1  4  0  1.0  0.0
FR 0  1  0  0  299.8
RP 0  91  91  1000  0.  0.  2.  4.
EN
```

NBS 3 element
Yagi

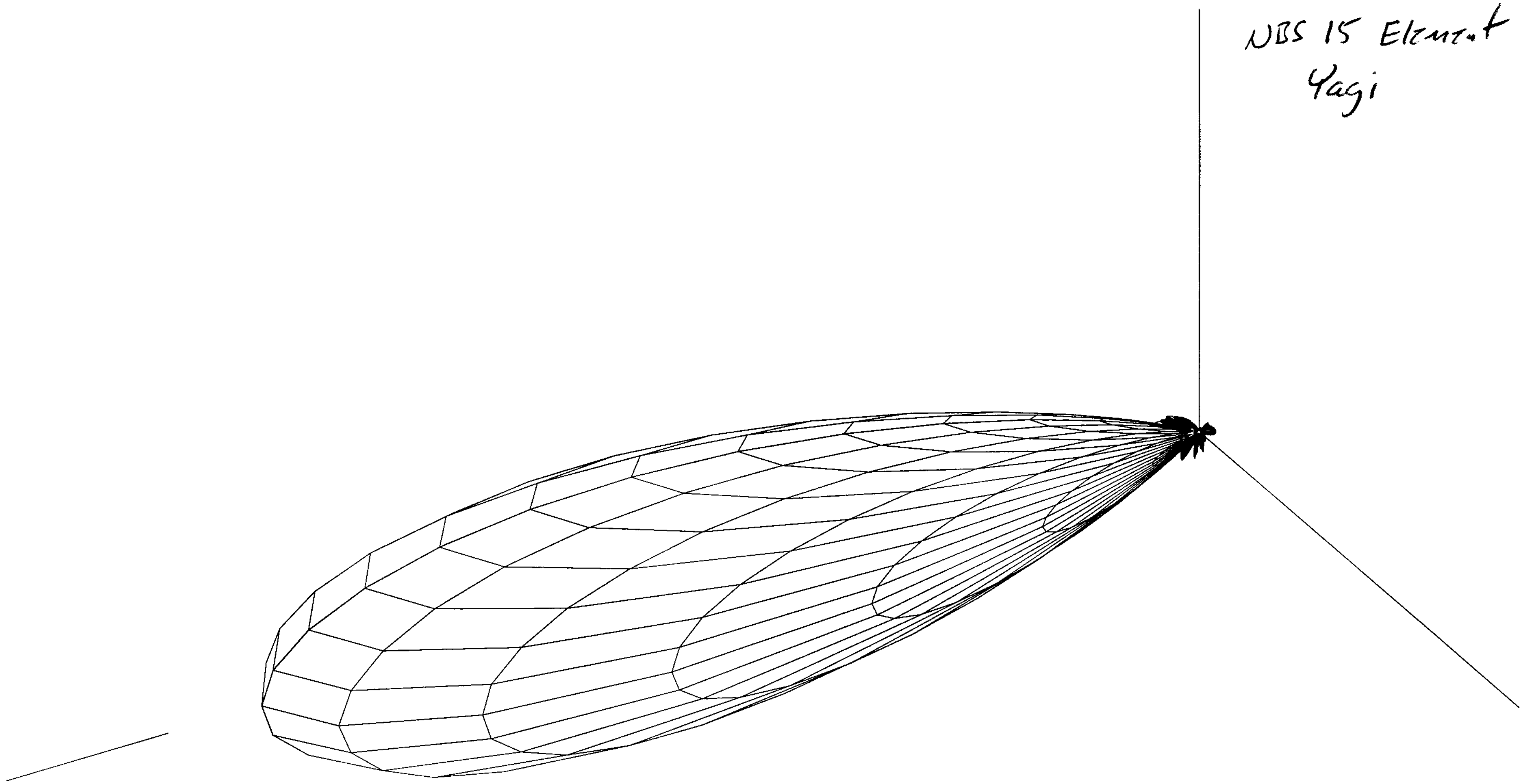


F = 3.00E+02 MHz

V. Gain: Max = 9.62 dB θmax = 90.0 view: θ = 60.0
Linear scale Ømax = 0.0 Ø = 60.0

```
CM EXAMPLE #2
CM UDA-YAGI ANTENNA
CE NBS 15 ELEMENT DESIGN
GW 1  7  0.     0. -0.22475  0.   0. 0.22475 0.00425
GW 2  7 -0.2    0. -0.2375 -0.2 0.  0.2375  0.00425
GW 3  7  0.308 0. -0.212   0.308 0. 0.212   0.00425
GW 4  7  0.616 0. -0.212   0.616 0. 0.212   0.00425
GW 5  7  0.924 0. -0.21    0.924 0. 0.21    0.00425
GW 6  7  1.232 0. -0.2035 1.232 0. 0.2035 0.00425
GW 7  7  1.540 0. -0.2015 1.540 0. 0.2015 0.00425
GW 8  7  1.848 0. -0.199   1.848 0. 0.199   0.00425
GW 9  7  2.156 0. -0.197   2.156 0. 0.197   0.00425
GW 10 7  2.464 0. -0.195   2.464 0. 0.195   0.00425
GW 11 7  2.772 0. -0.195   2.772 0. 0.195   0.00425
GW 12 7  3.080 0. -0.195   3.080 0. 0.195   0.00425
GW 13 7  3.388 0. -0.195   3.388 0. 0.195   0.00425
GW 14 7  3.696 0. -0.195   3.696 0. 0.195   0.00425
GW 15 7  4.004 0. -0.195   4.004 0. 0.195   0.00425
GE
EX 0  1  4  0  1.0  0.0
FR 0  1  0  0  299.8
RP 0  91  91  1000  0.  0.  2.  4.
EN
```

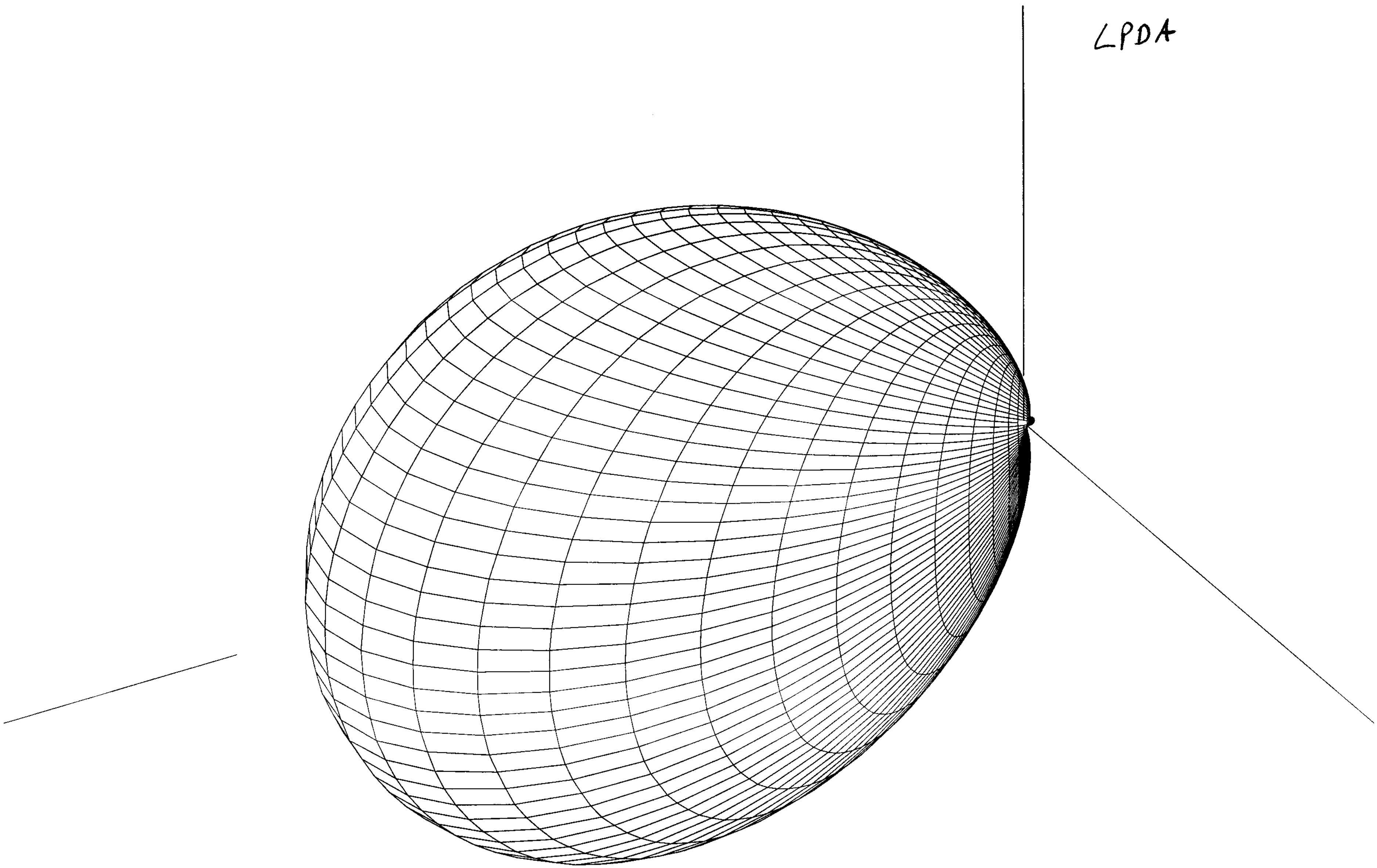
NBS 15 Element
Yagi



F = 3.00E+02 MHz

V. Gain: Max = 16.04 dB	θmax = 90.0	view: θ = 60.0
Linear scale	Ømax = 0.0	Ø = 60.0

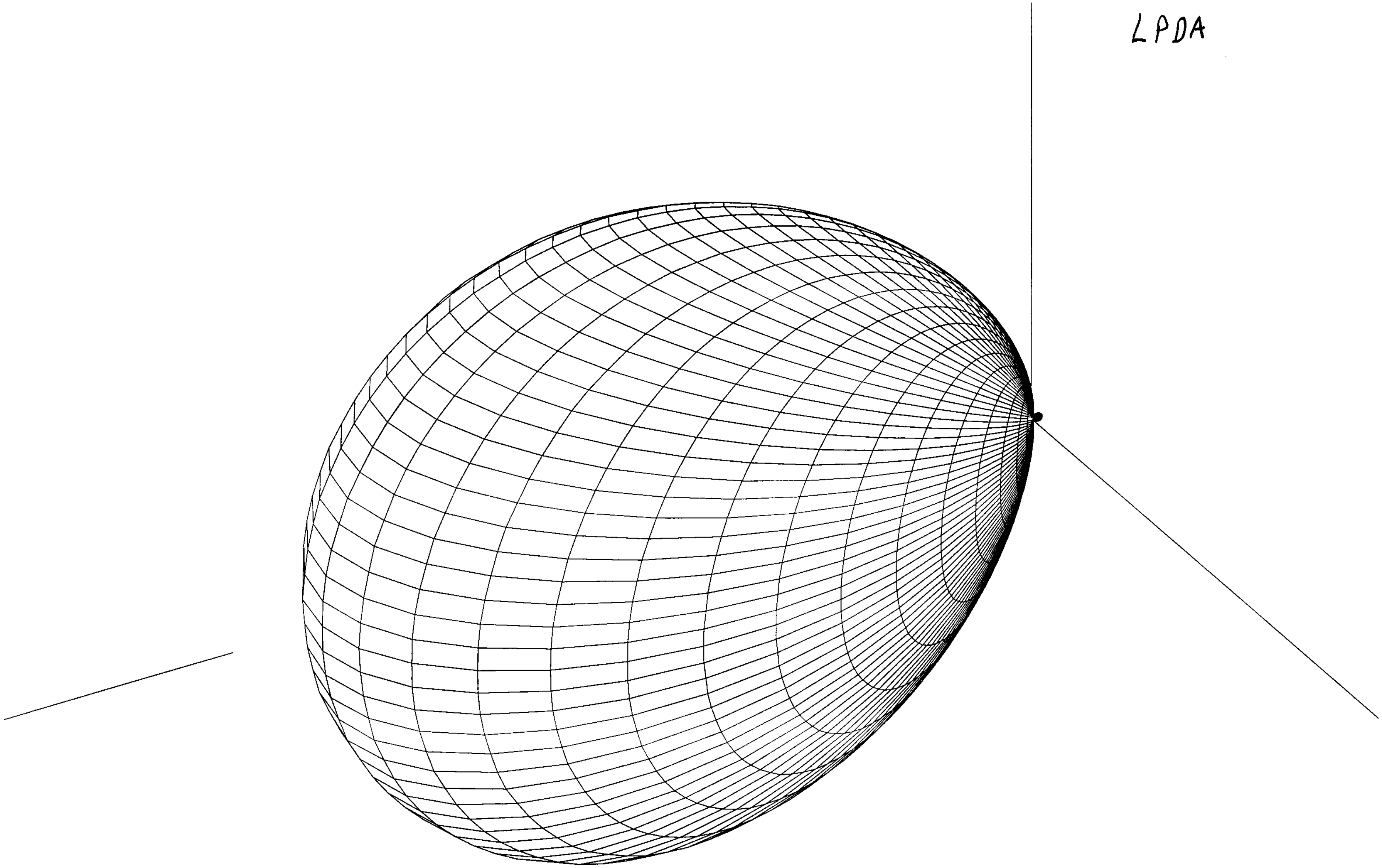
```
CM EXAMPLE #3
CM LOG-PERIODIC DIPOLE ARRAY
CM 7.5DB, SIGMA=0.158, TAU=.863
CM L11=0.778 M L1=3.393 M
CM 75 OHM INPUT IMPEDANCE
CM 11 ELEMENTS, K=L/D=130
CE 50MHZ < F < 100MHZ
GW 1  7   0.       -0.3890  0.  0.       0.3890  0.  0.0032
GW 2  7  -0.2854  -0.4506  0. -0.2854  0.4506  0.  0.0032
GW 3  7  -0.6161  -0.5222  0. -0.6161  0.5222  0.  0.0040
GW 4  7  -0.9993  -0.6051  0. -0.9993  0.6051  0.  0.0048
GW 5  7  -1.4432  -0.7011  0. -1.4432  0.7011  0.  0.0056
GW 6  7  -1.9576  -0.8123  0. -1.9576  0.8123  0.  0.0064
GW 7  7  -2.5536  -0.9411  0. -2.5536  0.9411  0.  0.0072
GW 8  7  -3.2442  -1.0905  0. -3.2442  1.0905  0.  0.0088
GW 9  7  -4.0444  -1.2635  0. -4.0444  1.2635  0.  0.0096
GW 10 7  -4.9715  -1.4640  0. -4.9715  1.4640  0.  0.0111
GW 11 7  -6.0457  -1.6963  0. -6.0457  1.6963  0.  0.0126
GE
TL  1  4  2   4  -86
TL  2  4  3   4  -86
TL  3  4  4   4  -86
TL  4  4  5   4  -86
TL  5  4  6   4  -86
TL  6  4  7   4  -86
TL  7  4  8   4  -86
TL  8  4  9   4  -86
TL  9  4  10  4  -86
TL 10  4  11  4  -86
EX 0  1  4  0  1.0  0.0
FR 0  6  0  0  50.  10.
RP 0  91  91  1000  0.  0.  2.  4.
EN
```



F = 5.00E+01 MHz

T. Gain: Max = 8.27 dB θmax = 88.0 view: θ = 60.0

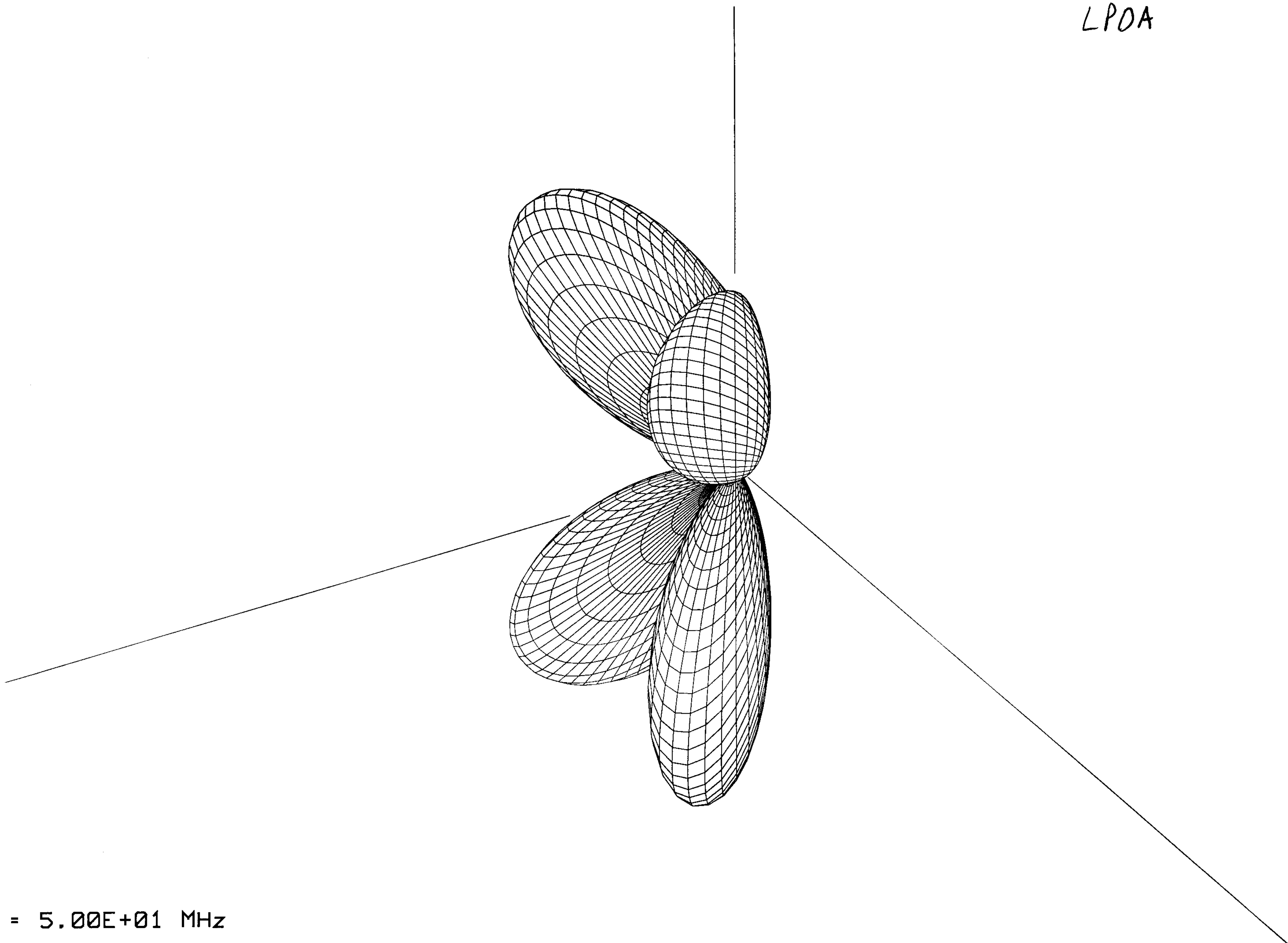
Linear scale Ømax = 0.0 Ø = 60.0



F = 5.00E+01 MHz

H. Gain: Max = 8.27 dB   θmax = 88.0   view: θ = 60.0
Linear scale   Ømax = 0.0   Ø = 60.0

LPOA



F = 5.00E+01 MHz

V. Gain: Max = -2.97 dB

Linear scale

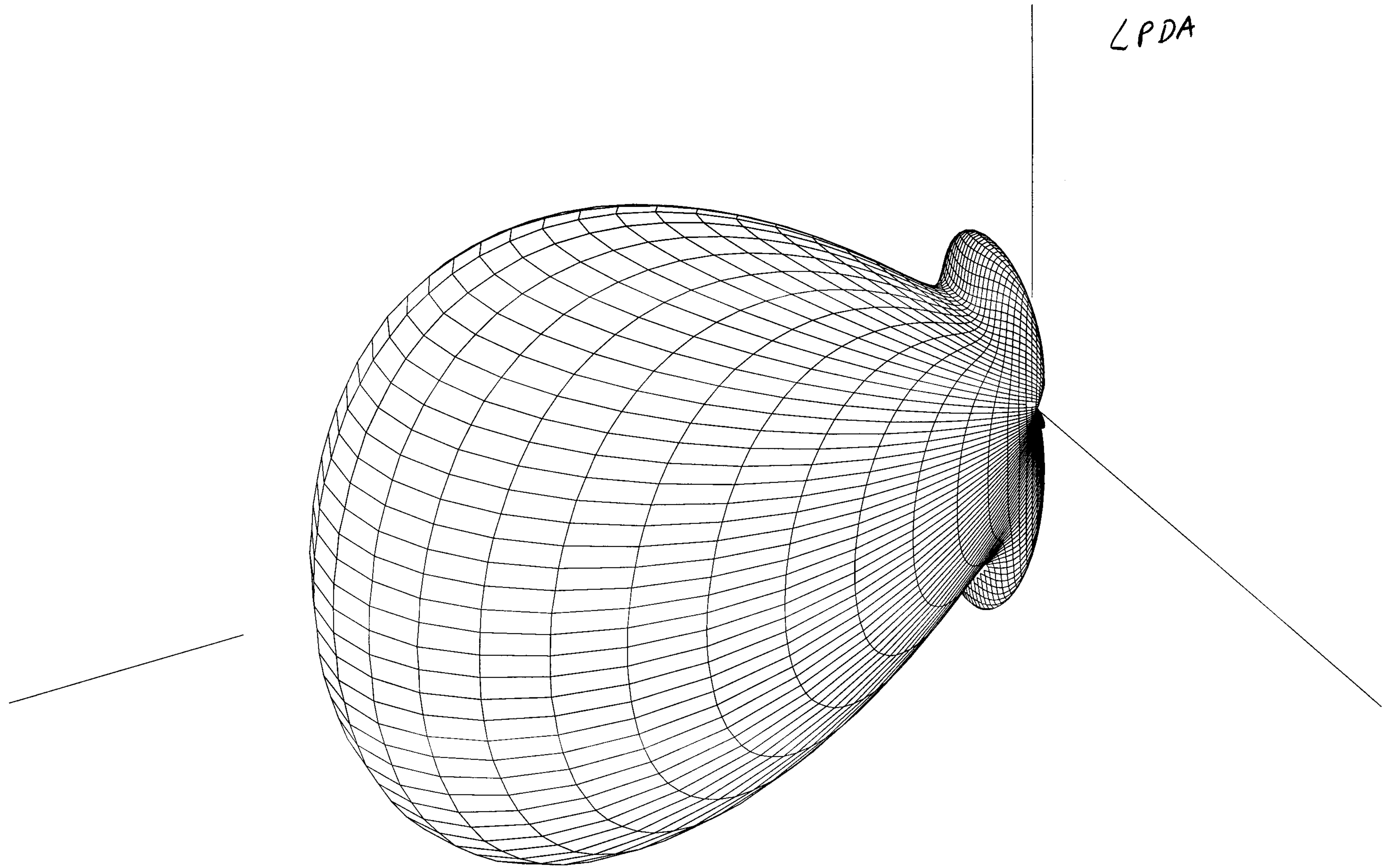
θmax = 38.0

Ømax = 48.0

view: θ = 60.0

Ø = 60.0

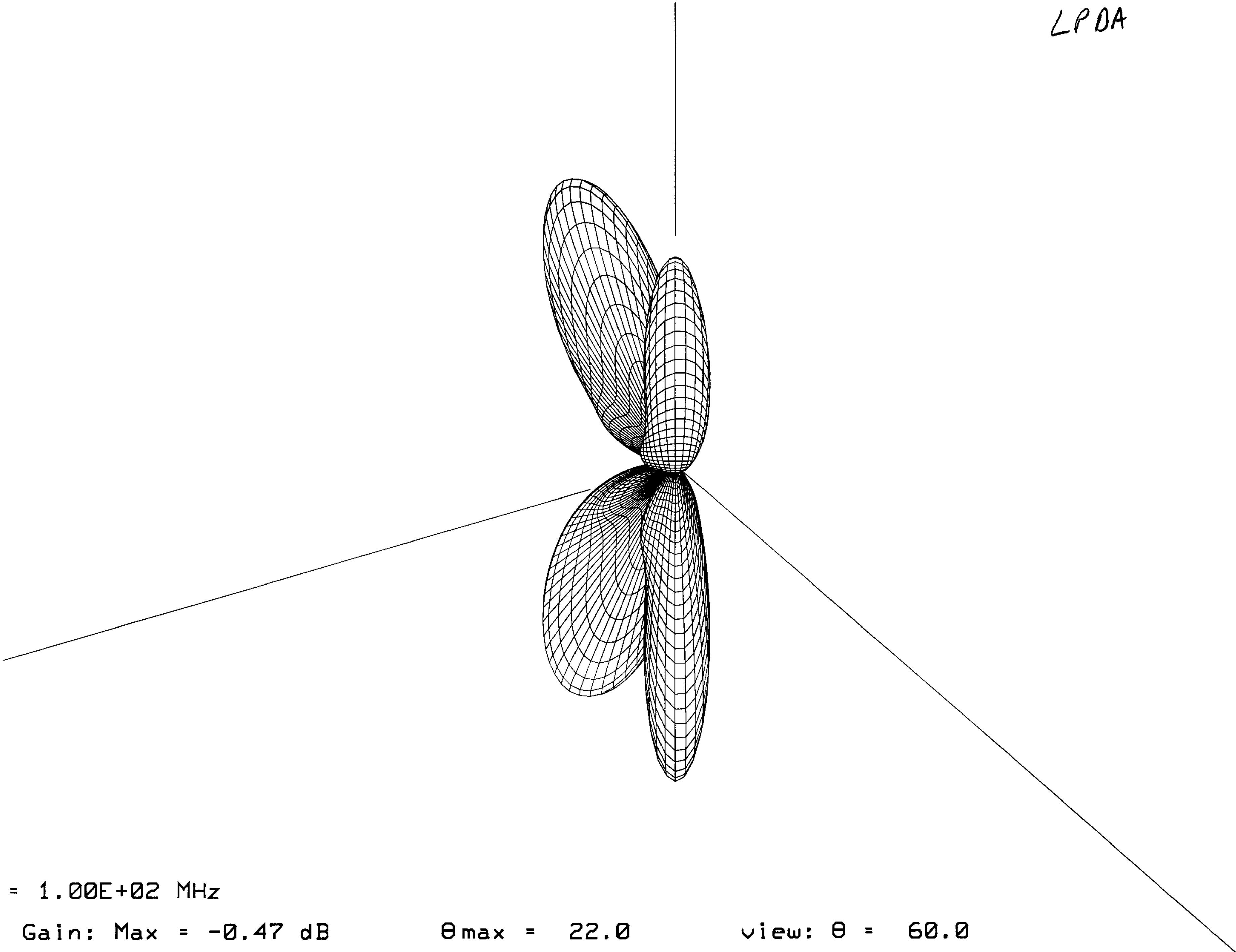
LPDA



F = 1.00E+02 MHz

T. Gain: Max = 8.25 dB	θmax = 88.0	view: θ = 60.0
Linear scale	Ømax = 0.0	Ø = 60.0

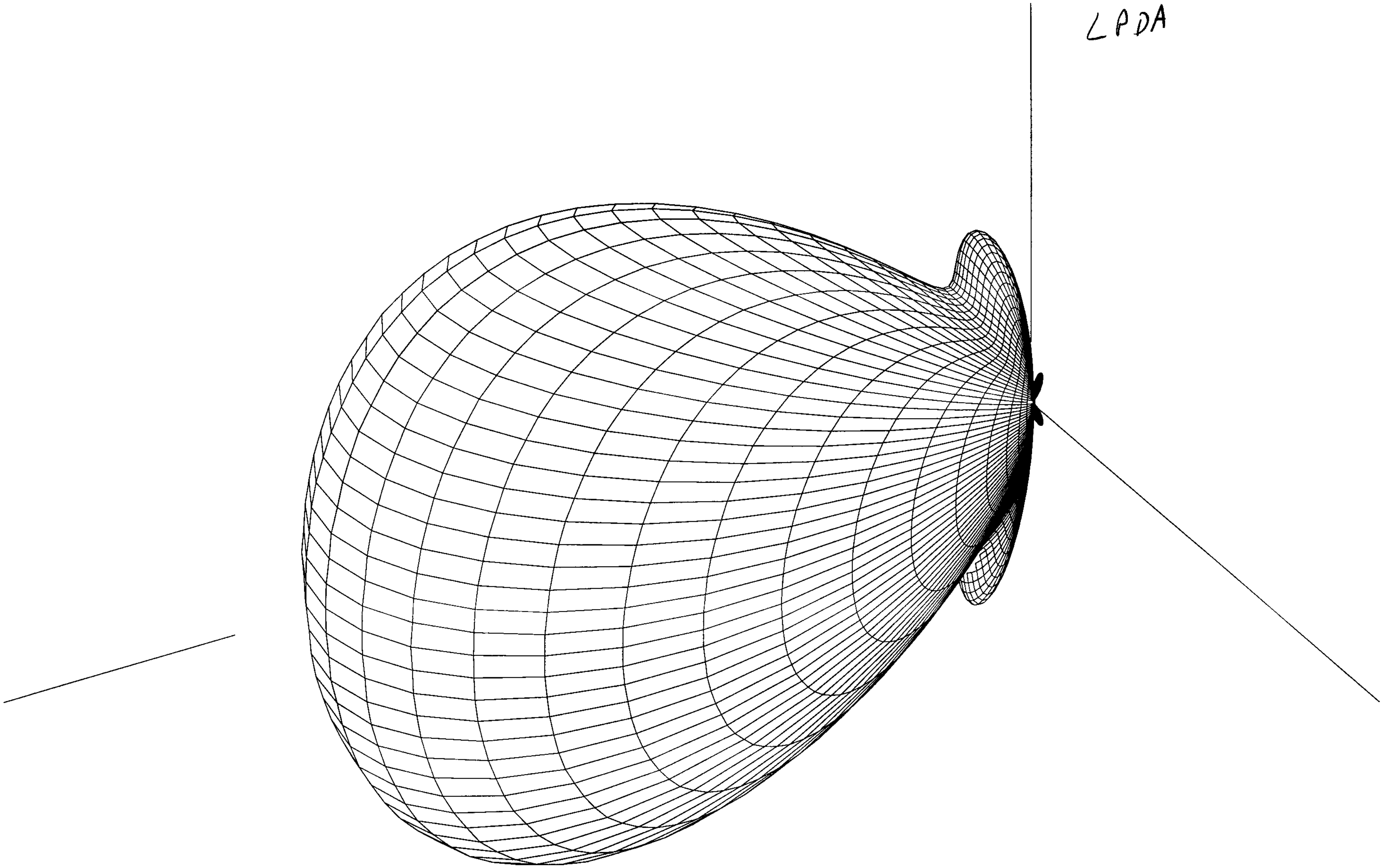
LPDA



F = 1.00E+02 MHz

V. Gain: Max = -0.47 dB	θmax = 22.0	view: θ = 60.0
Linear scale	Ømax = 60.0	Ø = 60.0

LPDA



F = 1.00E+02 MHz

H. Gain: Max = 8.25 dB | θmax = 88.0 | view: θ = 60.0
Linear scale | Ømax = 0.0 | Ø = 60.0