

Microwave Circuits and Antenna Design

Antenna Design

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Notation

c = speed of light in free space

λ_0 = wavelength of free space

k_0 = wavenumber of free space

k_1 = wavenumber of substrate

η_0 = intrinsic impedance of free space

η_1 = intrinsic impedance of substrate

ϵ_r = relative permittivity (dielectric constant) of substrate

ϵ_r^{eff} = effective relative permittivity
(accounting for fringing of flux lines at edges)

ϵ_{rc}^{eff} = complex effective relative permittivity
(used in the cavity model to account for all losses)

$$c = 2.99792458 \times 10^8 \text{ [m/s]}$$

$$\lambda_0 = c / f$$

$$k_0 = \omega \sqrt{\mu_0 \epsilon_0} = 2\pi / \lambda_0$$

$$k_1 = k_0 \sqrt{\epsilon_r}$$

$$\eta_0 = \sqrt{\frac{\mu_0}{\epsilon_0}} \approx 376.7303 \text{ [\Omega]}$$

$$\eta_1 = \eta_0 / \sqrt{\epsilon_r}$$

$$c = \frac{1}{\sqrt{\epsilon_0 \mu_0}}$$

$$\mu_0 = 4\pi \times 10^{-7} \text{ [H/m]}$$

$$\epsilon_0 = \frac{1}{\mu_0 c^2} \approx 8.854188 \times 10^{-12} \text{ [F/m]}$$

Antenna

- Anten, hava ile elektronik cihazlar arasındaki geçiş yapısıdır. Antenler, elektrik sinyallerini havaya elektromanyetik dalga olarak ışırlar, havadaki elektromanyetik sinyalleri ise elektrik sinyaline dönüştürürler.
- A usually metallic device (as a rod or wire) is used for radiating or receiving electromagnetic waves. An antenna is a transitional structure between free-space and a guiding structure (Balanis; Antenna Theory). Ortamda ortama geçişin efektif alanı, antenin efektif ışıma alanıdır.
- Antenna is a device that converts electrons into photons or vice versa. A transmitting antenna converts electrons into photons while a receiving antenna converts photons into electrons.
- The beam width of an antenna measure at half of the maximum power received by an antenna or the 3 dB beam width of the antenna is termed as half null beam width.
- Power radiated from an antenna per unit solid angle is called radiation intensity. Unit of radiation intensity is watts per steradian or per square degree.

Antenna Performance Parameters

Antenna parameters

- Radiation resistance
- Directivity
- Antenna gain
- Beamwidth
- Effective aperture
- Friis transmission equation

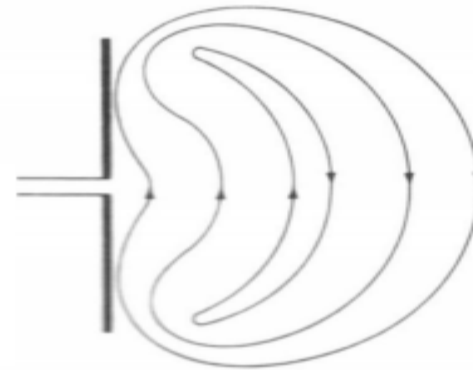
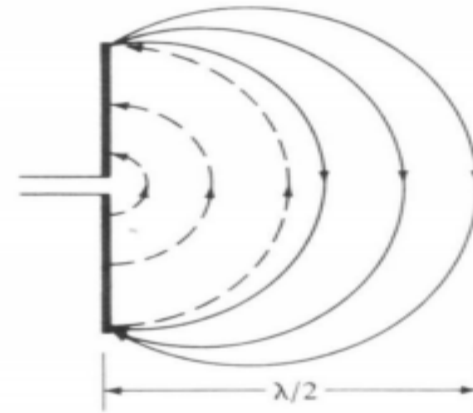
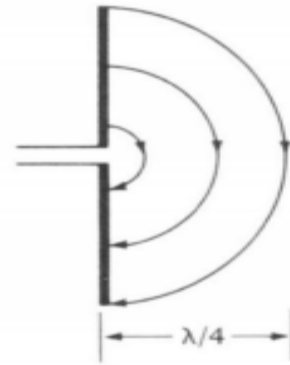
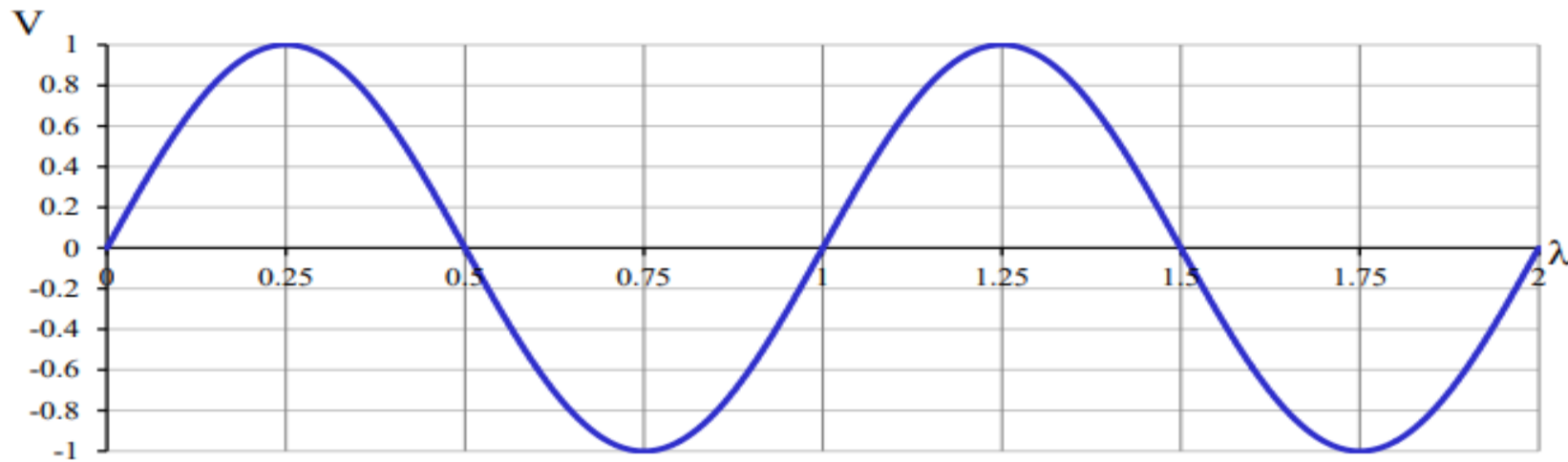
$$\frac{P_r}{P_t} = \frac{G_t G_r \lambda^2}{(4\pi R)^2} = \frac{A_{e,t} A_{e,r}}{\lambda^2 R^2}$$

Antenna Performance Parameters

- Common antenna performance parameters include:
 - Return Loss - Impedance
 - Gain and Directivity
 - Frequency coverage
 - Bandwidth
 - Beamwidth
 - Polarization
 - Efficiency
 - Field Patterns
 - Front to Back Ratio and Side lobes

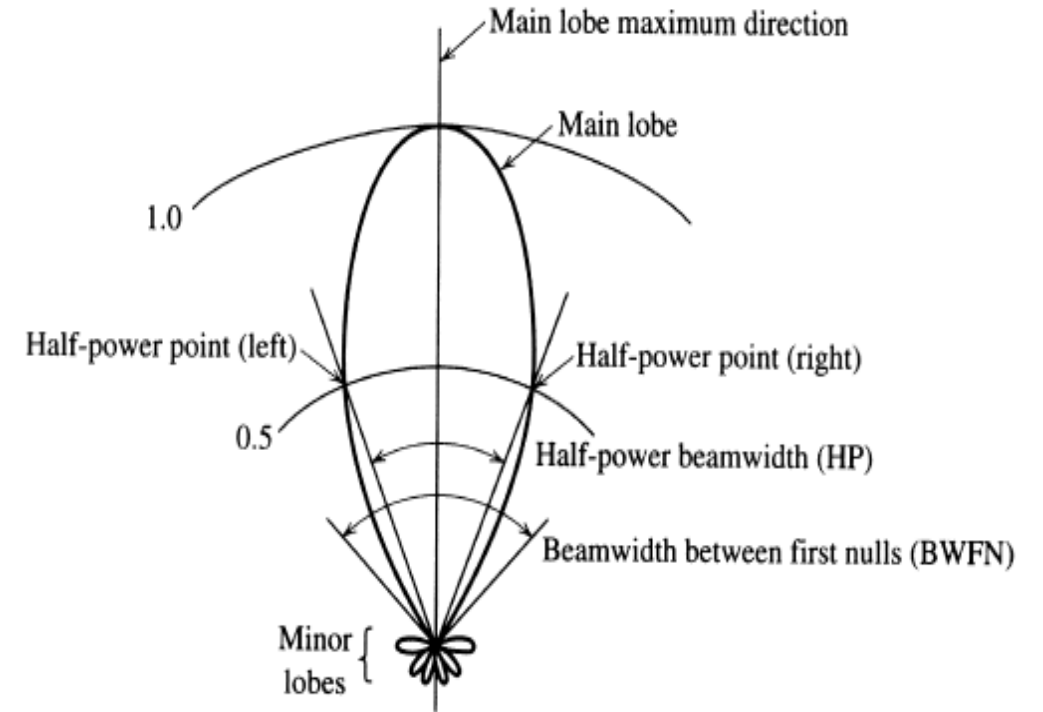
Antenna Basics

- How is radiation achieved?
- Wavelength is key: $\frac{\lambda}{2}$, where $\lambda = \frac{c_0}{f_r \sqrt{\epsilon_r}}$



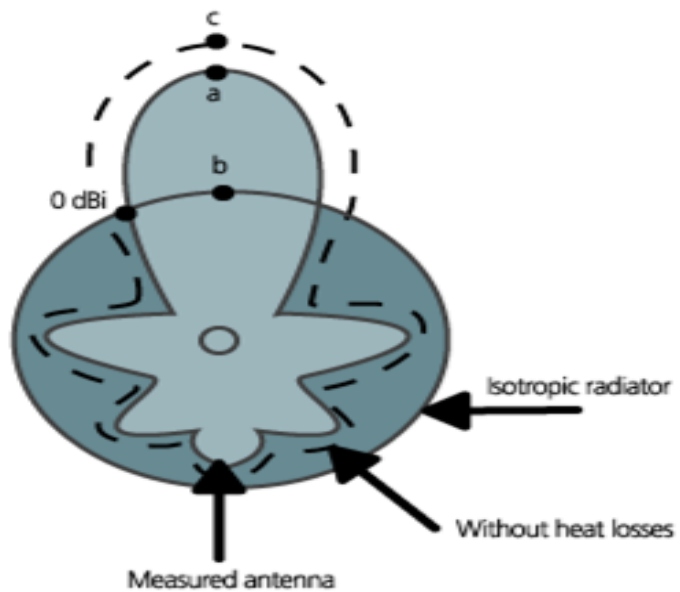
Beamwidth (θ_B , Φ_B)

- **Beamwidth** (θ_B , Φ_B) of an antenna is the angle defined by the points either side of boresight at which the power is reduced by 3-dB, for a given plane.
 - For example if θ_B represents the beamwidth in the horizontal plane, Φ_B represents the beamwidth in the orthogonal (vertical) plane.
 - **The 3-dB (Gücün yarıya düştüğü) beamwidth defines the half-power beam.**



dBi versus dBd

- **dBi** indicates gain vs. isotropic antenna
 - Isotropic antenna radiates equally well in all directions, spherical pattern, Gain=1, Gain(dBi)=0 dBi
- **dBd** indicates gain vs. reference half-wavelength dipole
 - Dipole has a doughnut shaped pattern with a gain of 2.15 dBi



$$dBi = dBd + 2.15 dB$$

Antenna Gain

- Relationship between antenna gain and effective area

$$G = \frac{4\pi A_e}{\lambda^2} = \frac{4\pi f^2 A_e}{c^2}$$

- G = antenna gain
- A_e = effective area
- f = carrier frequency
- c = speed of light (3×10^8 m/s)
- λ = carrier wavelength

ANTENNA BASICS

1. The Gain of an antenna with losses is given by:

$$G \approx \frac{4\pi\eta A}{\lambda^2} \quad \text{Where } \eta = \text{Efficiency}$$

$$A = \text{Physical aperture area}$$

$$\lambda = \text{wavelength}$$

another is:

$$G = \frac{X \eta}{BW_\phi BW_\theta}$$

Where BW_θ and ϕ are the elev & az beamwidths in degrees.

For approximating an antenna pattern with:

- (1) A rectangle; $X=41253, \eta_{\text{typical}}=0.7$
 (2) An ellipsoid; $X=52525, \eta_{\text{typical}}=0.55$

2. Gain of rectangular X-Band Aperture

$$G = 1.4 LW \quad \text{Where: Length (L) and Width (W) are in cm}$$

3. Gain of Circular X-Band Aperture

$$G = d^2 \eta \quad \text{Where: } d = \text{antenna diameter in cm}$$

$$\eta = \text{aperture efficiency}$$

4. Gain of an isotropic antenna radiating in a uniform spherical pattern is one (0 dB).

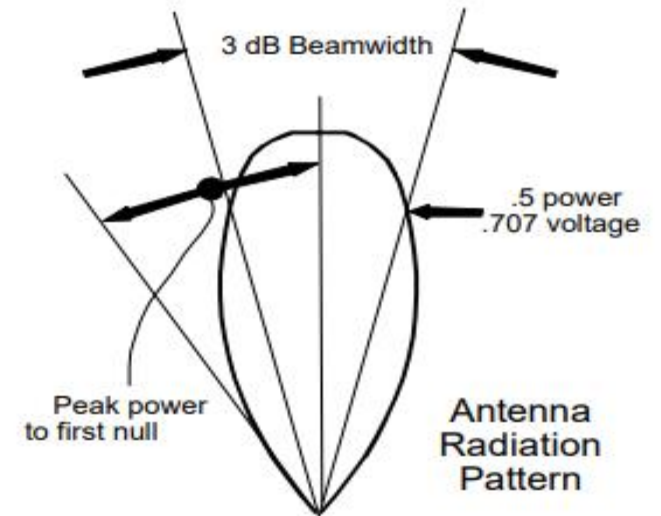
5. Antenna with a 20 degree beamwidth has a 20 dB gain.

6. 3 dB beamwidth is approximately equal to the angle from the peak of the power to the first null (see figure at right).

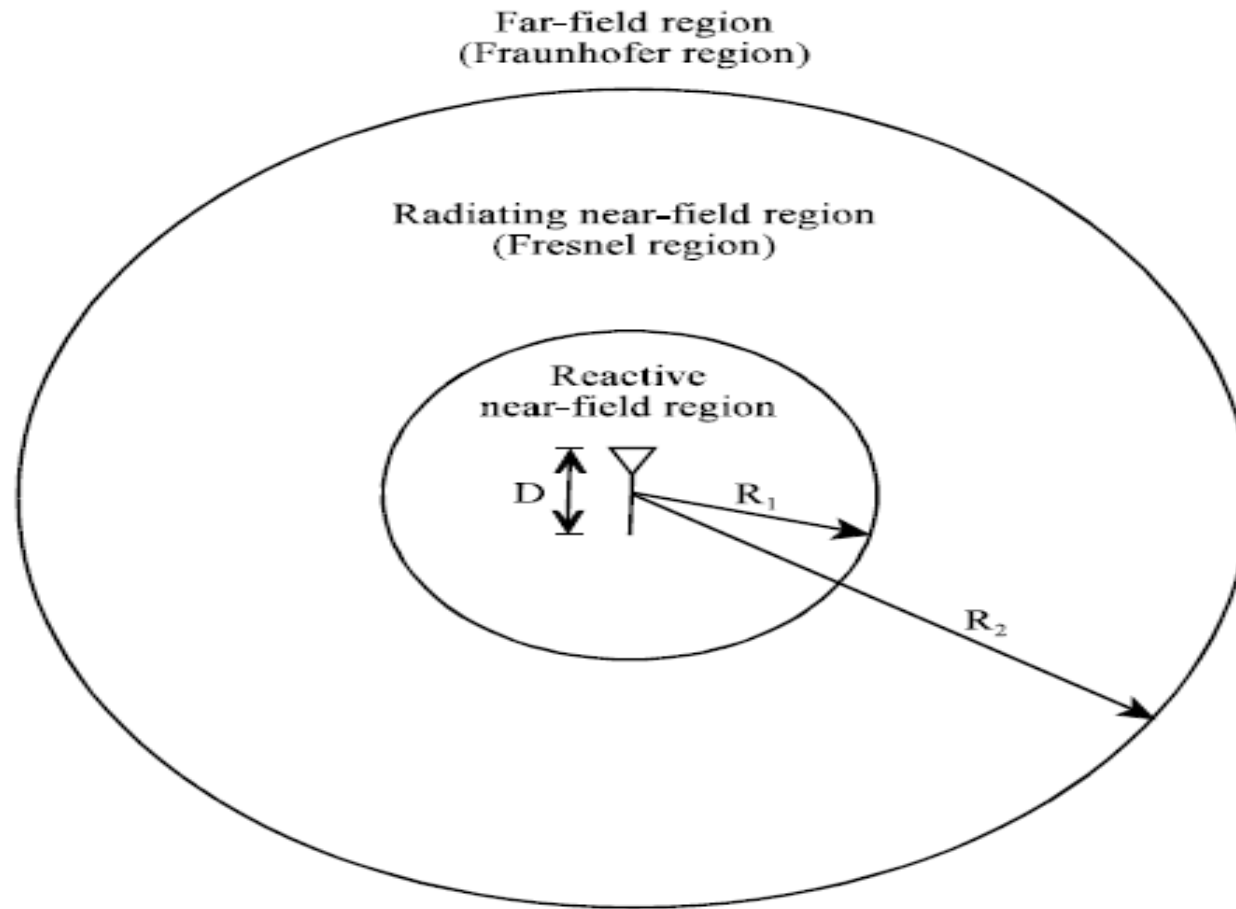
7. Parabolic Antenna Beamwidth:

$$BW = \frac{70\lambda}{d}$$

Where: BW = antenna beamwidth; λ = wavelength; d = antenna diameter.



Antenna Field Regions

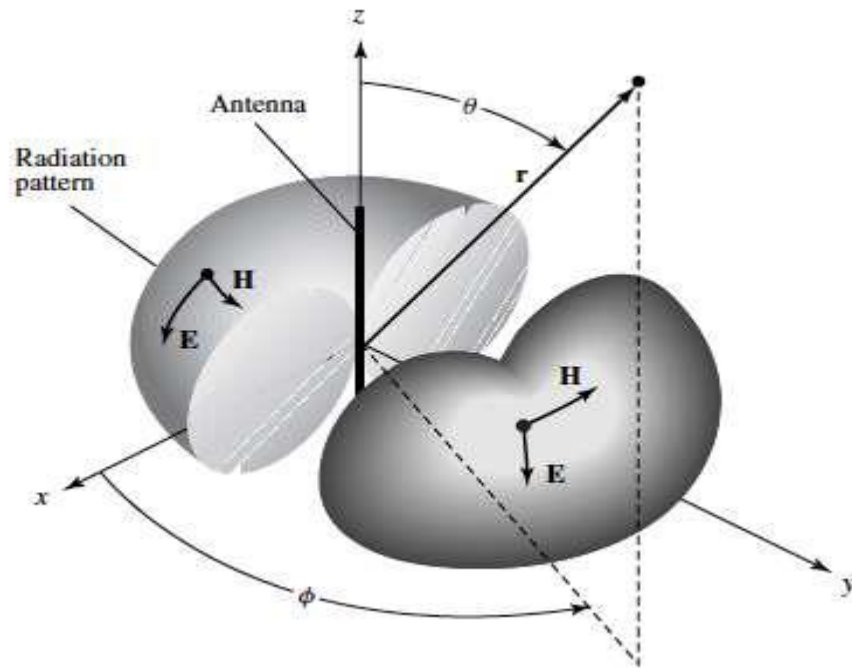


D = maximum antenna dimension

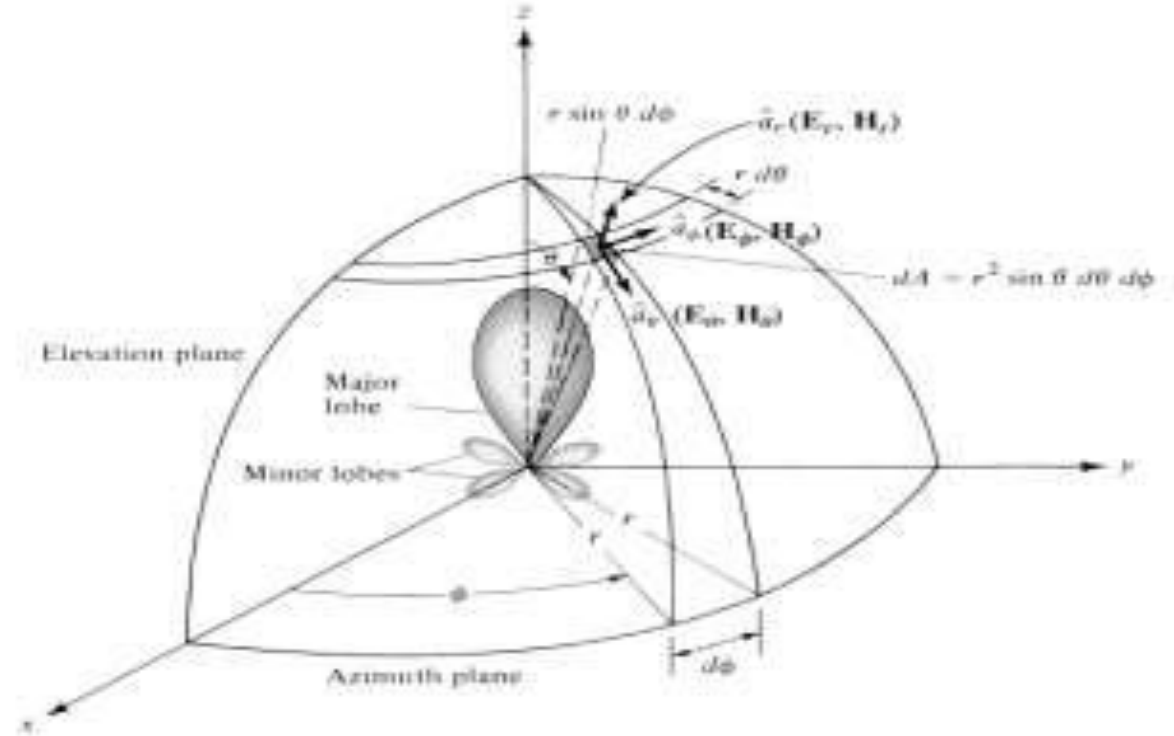
$$R_1 = 0.62 \sqrt{\frac{D^3}{\lambda}}$$

$$R_2 = \frac{2D^2}{\lambda}$$

Pattern of antennas

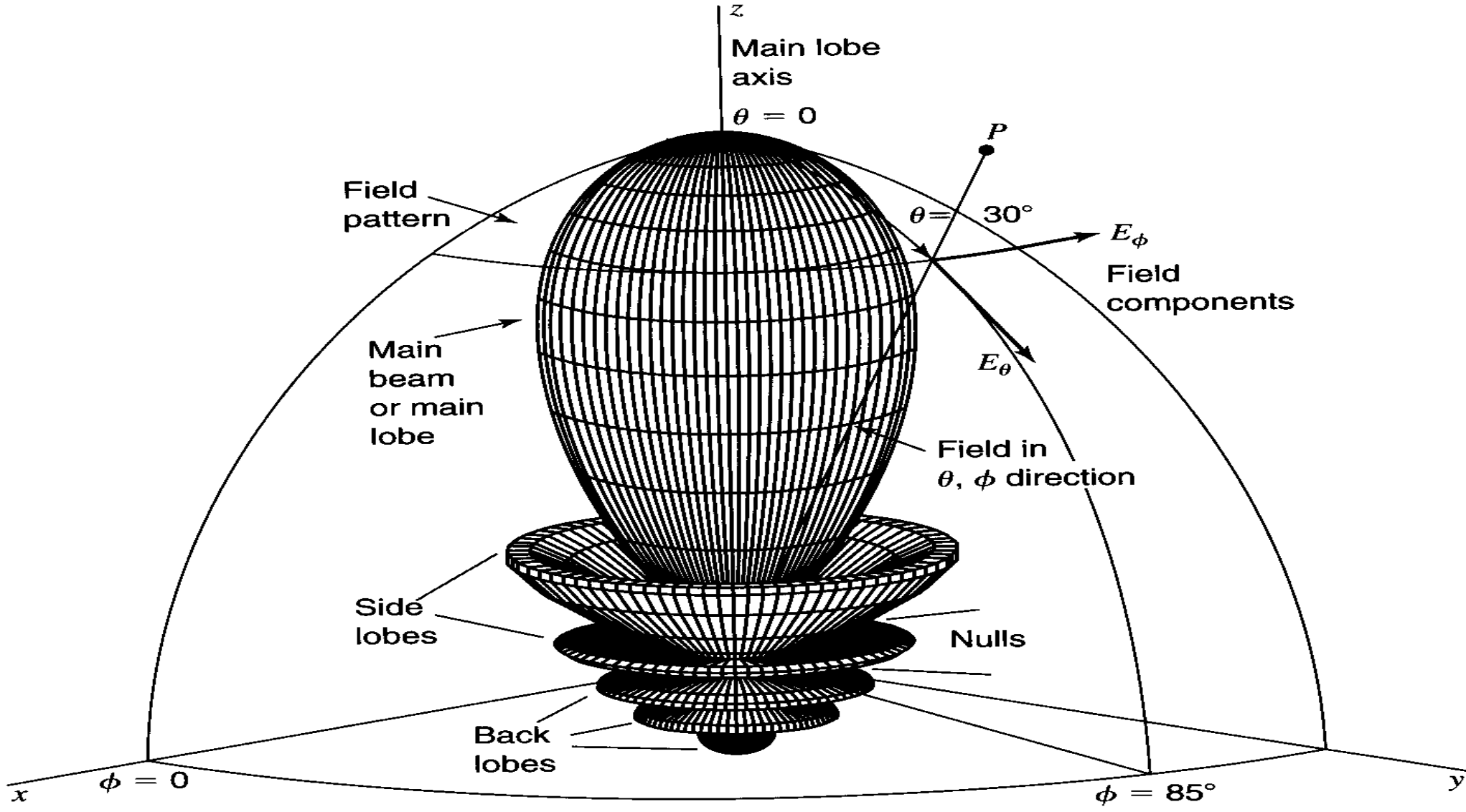


Isotropic, directional, and omnidirectional pattern

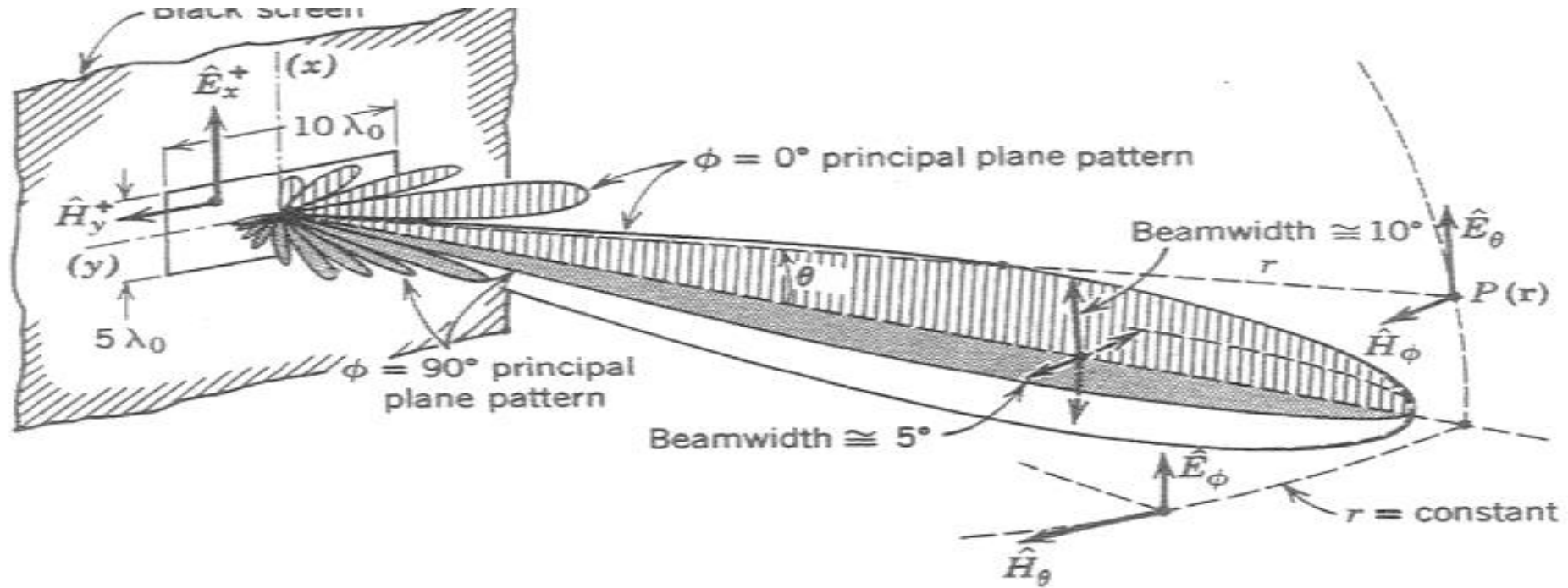


Radiation pattern

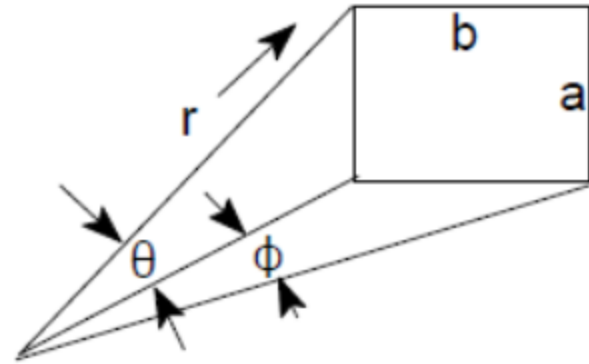
Radiation pattern



Antenna Pattern 3D



Approximating the antenna pattern as a rectangular area:



$$a = r \sin \theta, \quad b = r \sin \phi, \quad \text{area} = ab = r^2 \sin \theta \sin \phi$$

$$G = \frac{\text{Area of Sphere}}{\text{Area of Antenna pattern}} = \frac{4 \pi r^2}{r^2 \sin \theta \sin \phi} = \frac{4 \pi}{\sin \theta \sin \phi}$$

Where $\theta = BW_{\theta}$, and $\phi = BW_{\phi}$

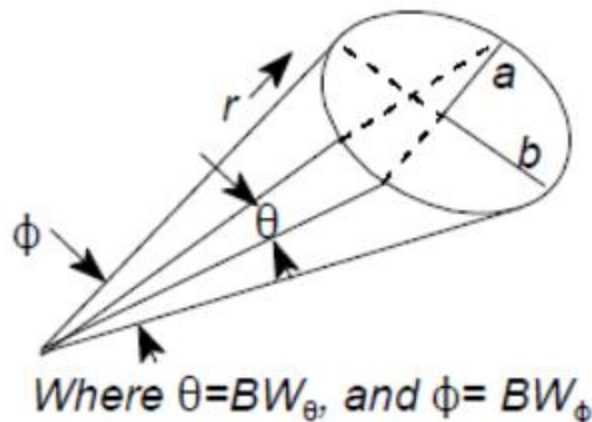
For small angles, $\sin \phi = \phi$ in radians, so:

$$G = \frac{4 \pi}{\sin \phi \sin \theta} = \frac{4 \pi}{\phi \theta \text{ (radians)}} = \frac{4 \pi \left(\frac{360^\circ}{2 \pi} \frac{360^\circ}{2 \pi} \right)}{\phi \theta \text{ (degrees)}} = \frac{41253}{\phi \theta \text{ (degrees)}} \text{ or } \frac{41253}{BW_{\phi} BW_{\theta} \text{ (degrees)}}$$

The second term in the equation above is identical to equation [3].

Converting to dB, $G_{\max}(dB) = 10 \text{ Log} \left[\frac{41253}{BW_{\phi} BW_{\theta}} \right]$ with BW_{ϕ} and BW_{θ} in degrees

Approximating the antenna pattern as an elliptical area:



$$\text{Area of ellipse} = \pi a b = \pi \left[\frac{r \sin \theta}{2} \right] \left[\frac{r \sin \phi}{2} \right] = \frac{\pi r^2 \sin \theta \sin \phi}{4}$$

$$G = \frac{\text{Area of Sphere}}{\text{Area of Antenna pattern}} = (4 \pi r^2) \left(\frac{4}{\pi r^2 \sin \theta \sin \phi} \right) = \frac{16}{\sin \theta \sin \phi}$$

For small angles, $\sin \phi = \phi$ in radians, so:

$$G = \frac{16}{\sin \phi \sin \theta} = \frac{16}{\phi \theta \text{ (radians)}} = \frac{16}{\phi \theta \left(\frac{360^\circ}{2\pi} \frac{360^\circ}{2\pi} \right)} = \frac{52525}{\phi \theta \text{ (degrees)}} \text{ or } \frac{52525}{BW_{\phi} BW_{\theta} \text{ (degrees)}}$$

For a very directional radar dish with a beamwidth of 1° and an average efficiency of 55%:

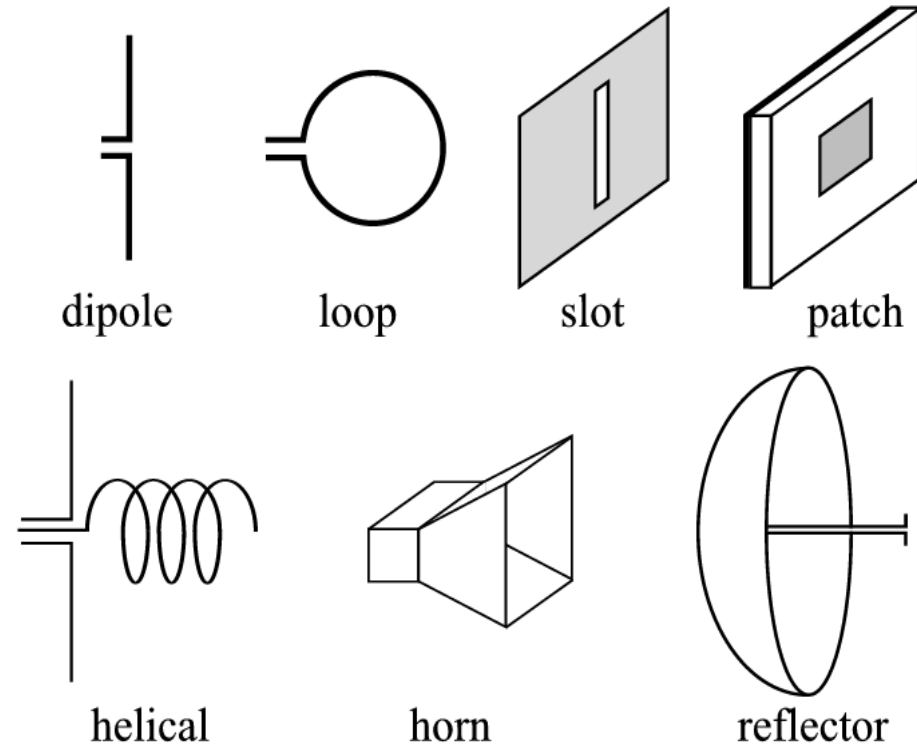
Ideally: $G = 52525$, or in dB form: $10 \log G = 10 \log 52525 = 47.2 \text{ dB}$

With efficiency taken into account, $G = 0.55(52525) = 28888$, or in log form: $10 \log G = 44.6 \text{ dB}$

Types of Antennas

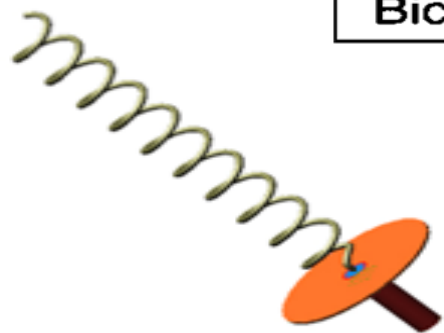
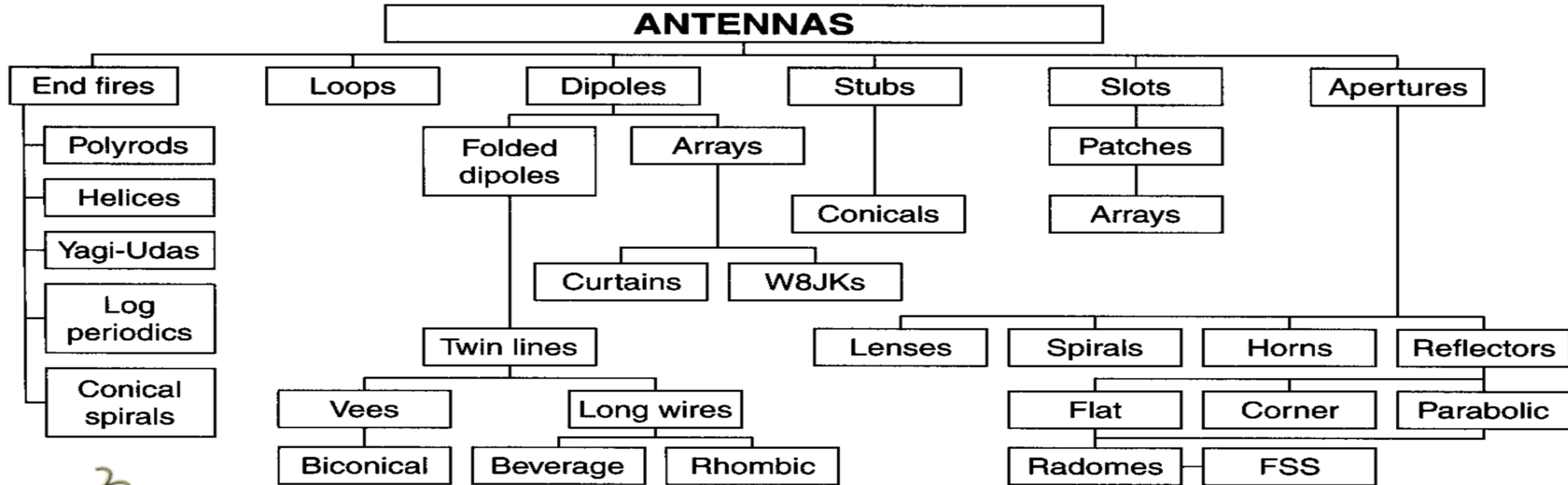
Types of Antennas

- Wire antennas
- Aperture antennas
- Array antennas
- Reflector antennas
- Lens antennas
- Patch antennas

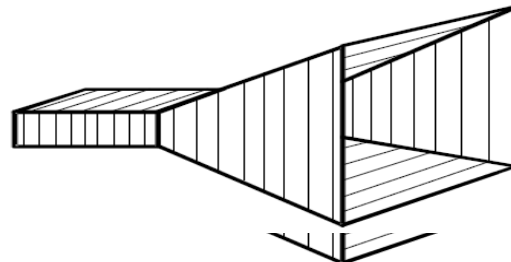


Antennas come in a wide variety of sizes and shapes

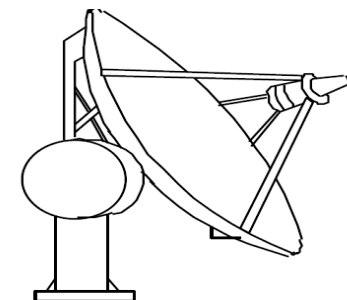
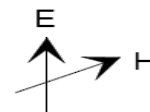
Antenna types



20 Helical antenna



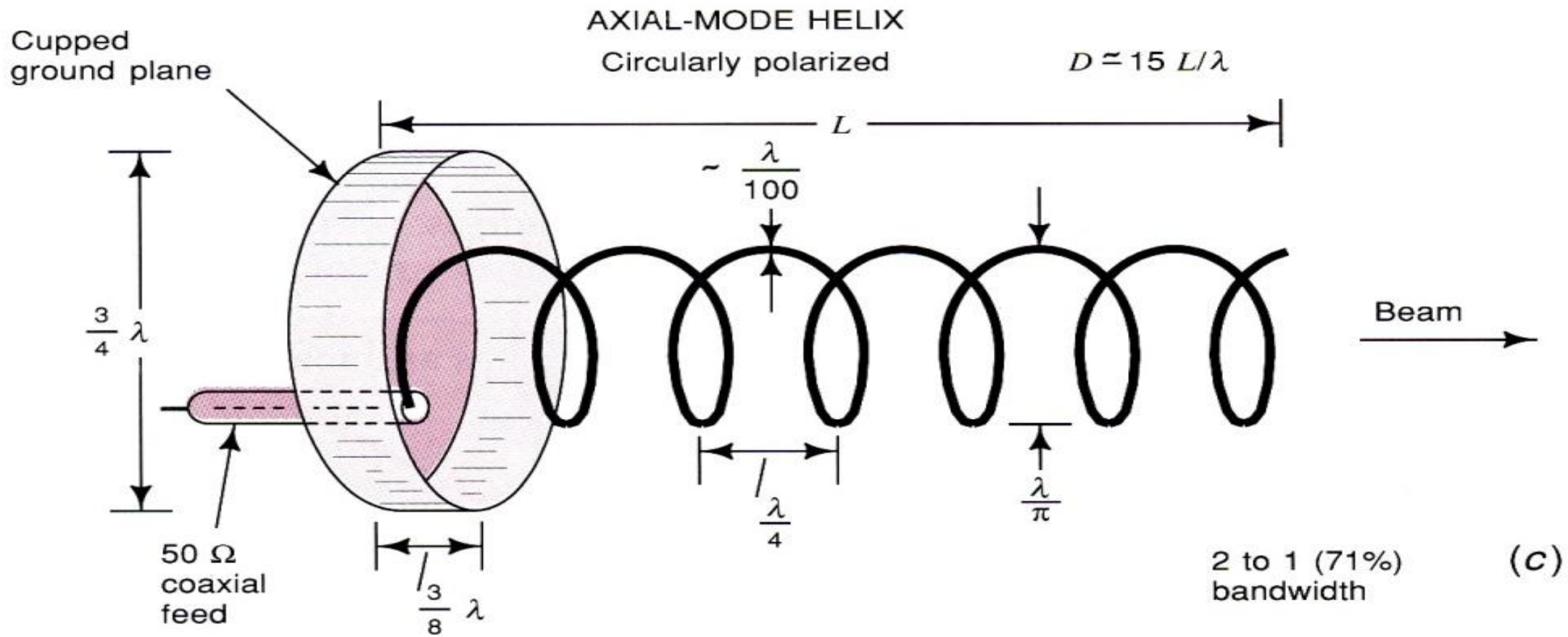
Horn antenna



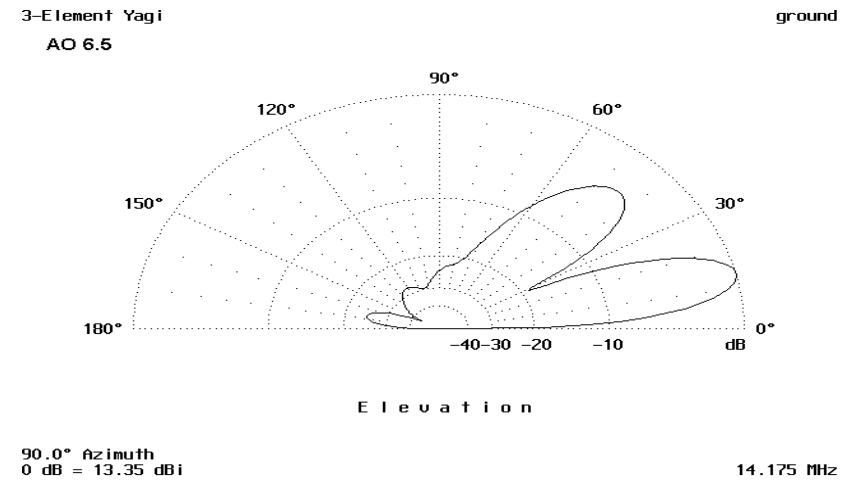
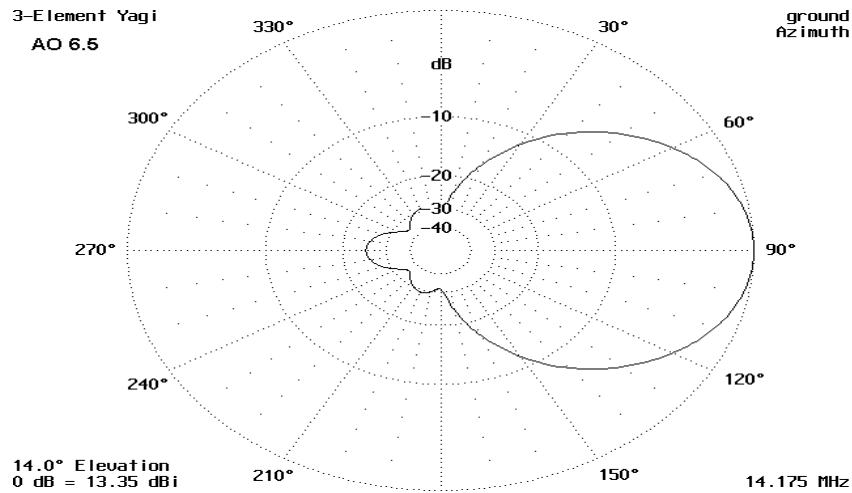
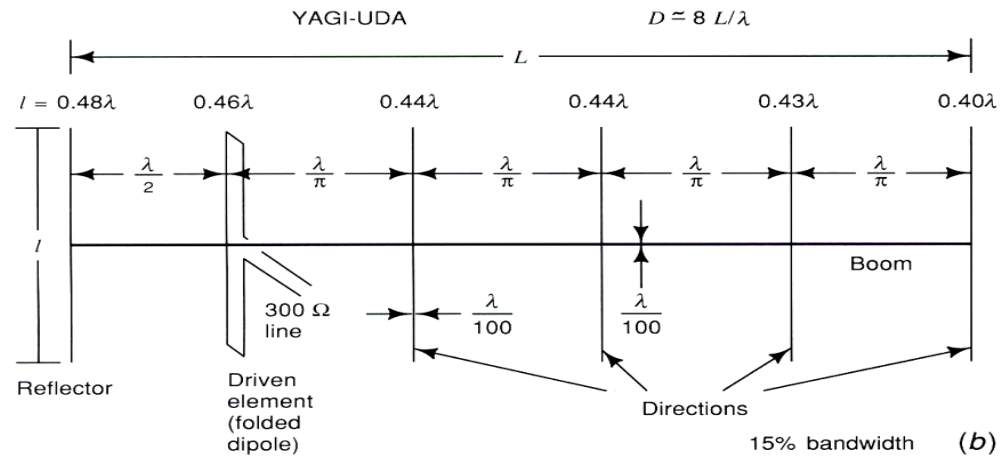
Parabolic reflector antenna

Different Antennas



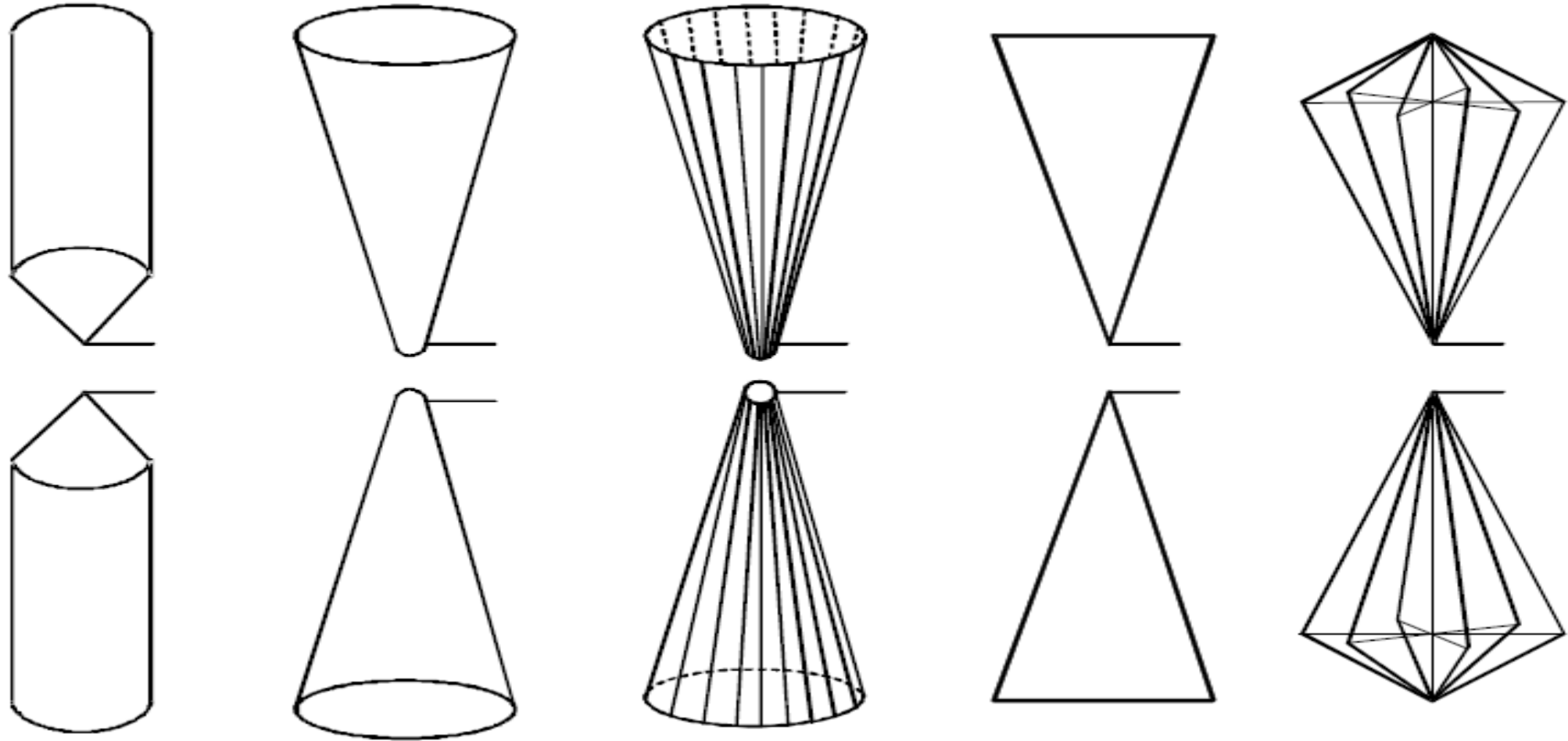


Yagi-Uda



Elements	Gain dBi	Gain dBd
3	7.5	5.5
4	8.5	6.5
5	10	8
6	11.5	9.5
7	12.5	10.5
8	13.5	11.5

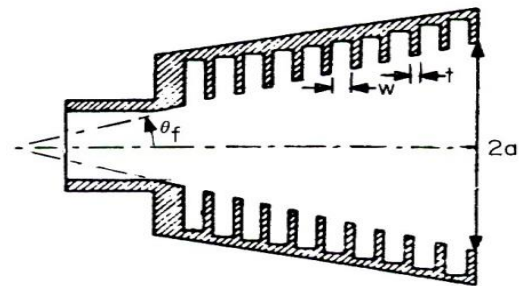
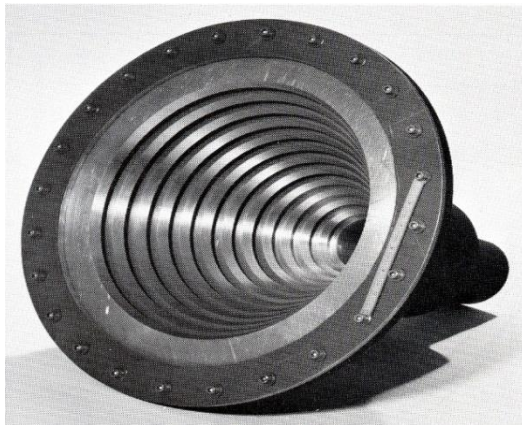
Dipole antennas



Versions of broadband dipole antennas

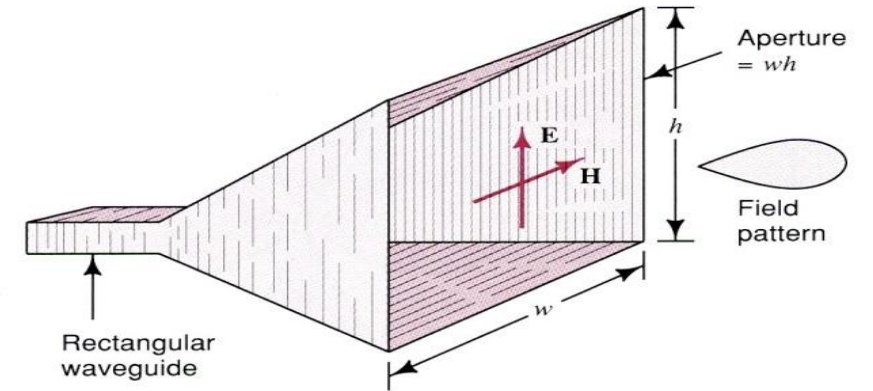
Horn antenna

- Rectangular or circular waveguide flared up
- Spherical wave fronts from phase centre
- Flare angle and aperture determine gain
- Aperture antennas derived from waveguide technology (circular, rectangular)
- Can transfer high power (magnetrons, klystrons)
- Above few GHz
- Will be explored inprace during the school



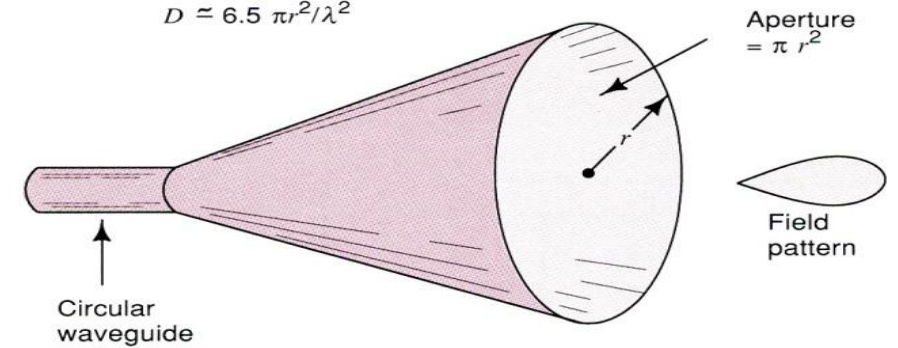
RECTANGULAR (PYRAMIDAL) HORN

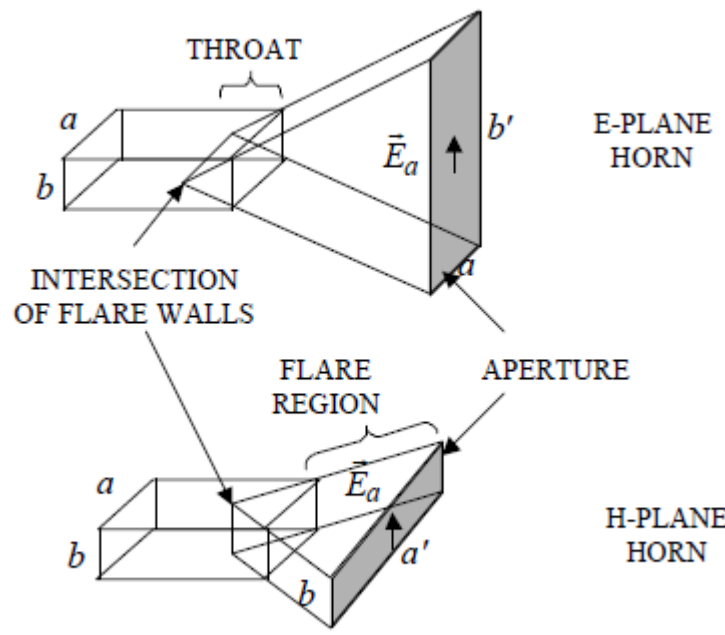
$$D \approx 7.5 \frac{wh}{\lambda^2}$$



CIRCULAR (CONICAL) HORN

$$D \approx 6.5 \frac{\pi r^2}{\lambda^2}$$





The aperture dimensions of a pyramidal horn are 12x6 cm and operating at a frequency of 10 GHz. Find the beam width and directivity.

Frequency = 10 GHz

$$\lambda = \frac{3 \times 10^8}{10 \times 10^9} = 3 \text{ cm}$$

$$d = 12 \text{ cm} \quad \text{and} \quad w = 6 \text{ cm}$$

$$\text{Beamwidth: } \phi_E = 56 \frac{\lambda}{d} = 14^\circ$$

$$\phi_H = 67 \frac{\lambda}{w} = 33.5^\circ$$

$$\text{power gain} = \frac{4.5wd}{\lambda^2} = 36 = 15.56 \text{ dB}$$

$$\text{Directivity} = \frac{7.5wd}{\lambda^2} = 60$$

Horn Example

Example: An E-plane horn has $R_1 = 20\lambda$ and $a = 0.5\lambda$.

(a) The optimum aperture dimension for maximum directivity

$$b' = \sqrt{2\lambda R_1} = \lambda\sqrt{40} = 6.3\lambda$$

(b) The flare angle for the optimum directivity

$$\tan(\psi/2) = \frac{b'/2}{R_1} = \frac{6.3\lambda/2}{20\lambda} = 0.1575$$

$$\psi/2 = 8.95^\circ$$

$$\psi = 17.9^\circ$$

(c) The optimum directivity is

$$D_{\text{opt}} = 10.2 \frac{(0.5\lambda)(6.3\lambda)}{\lambda^2} \left(\frac{1}{1.25} \right) = 25.7 = 14.1 \text{ dB}$$

Parabolic conducting reflector Geometry and operation

For a parabolic conducting reflector surface of focal length f with a feed at the focus F .

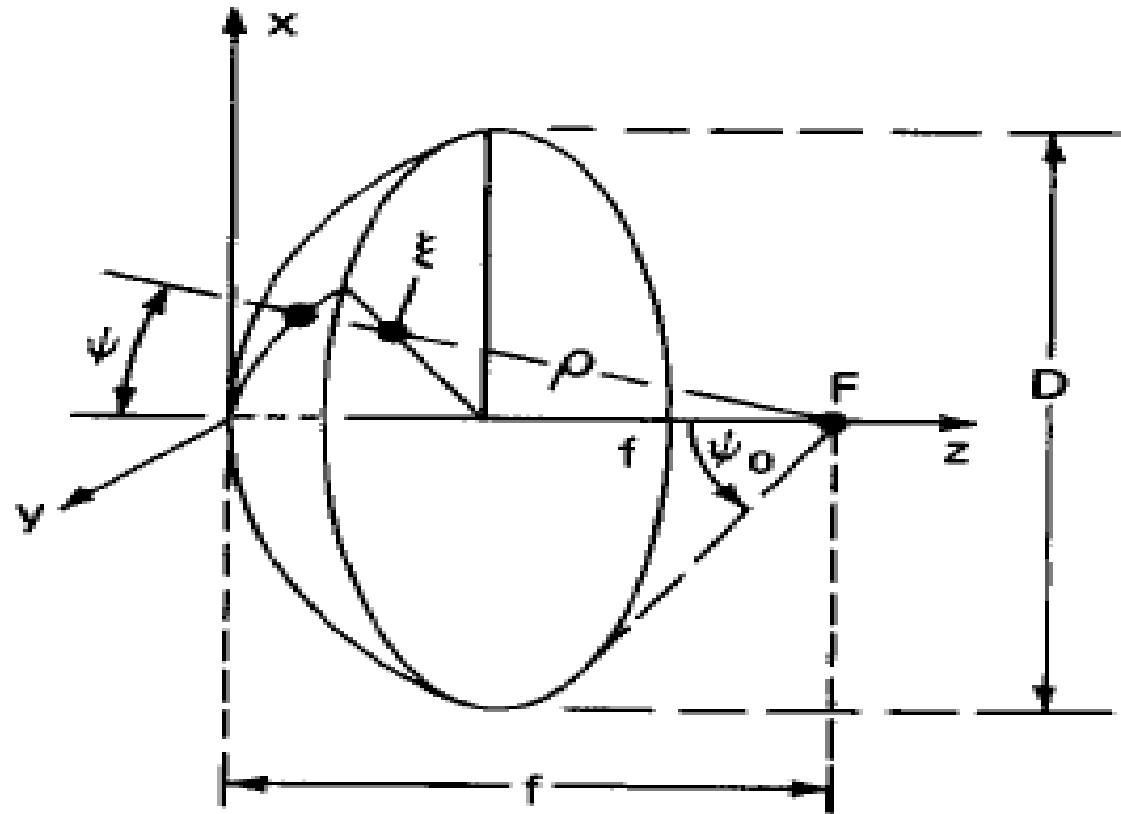
In rect. coordinates

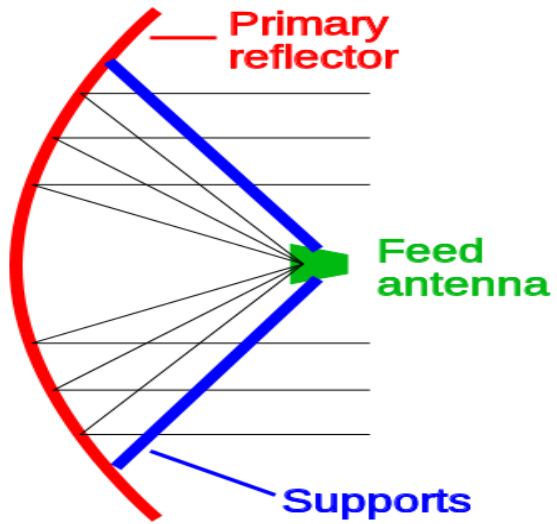
$$z = (x^2 + y^2)/4f$$

In spherical coordinates

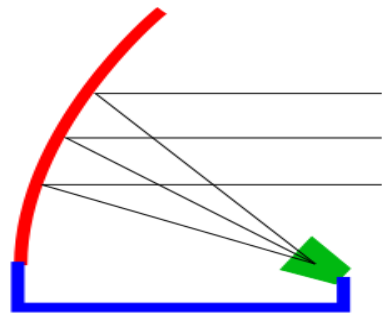
$$\rho = f \sec^2 \psi/2$$

$$\tan \psi_o/2 = D/4f$$

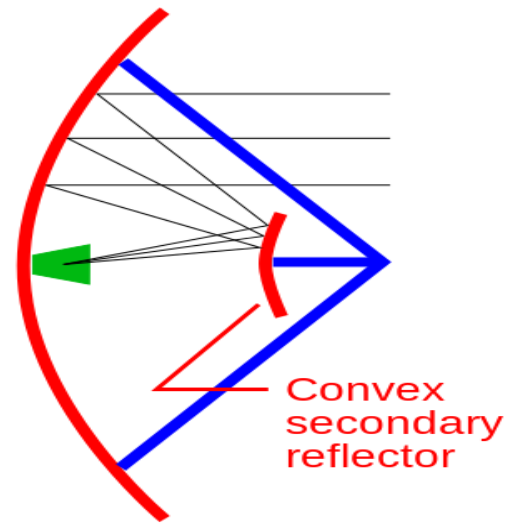




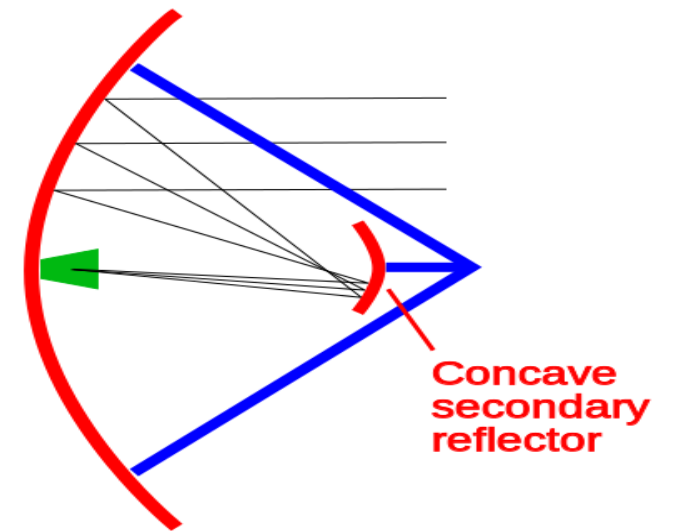
Axial-feed



Off-axis or
Offset-feed



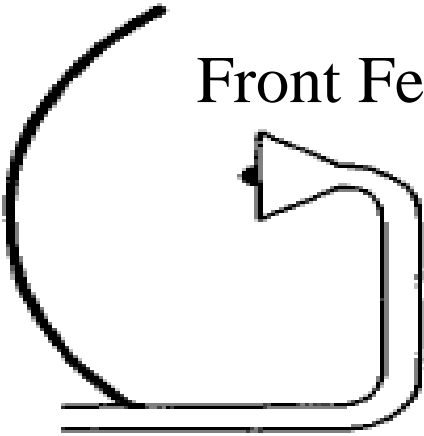
Cassegrain



Gregorian

Feeds

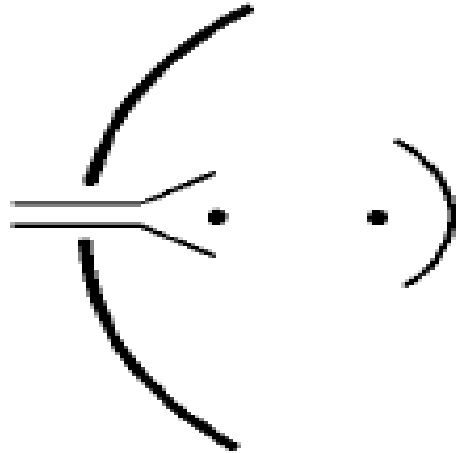
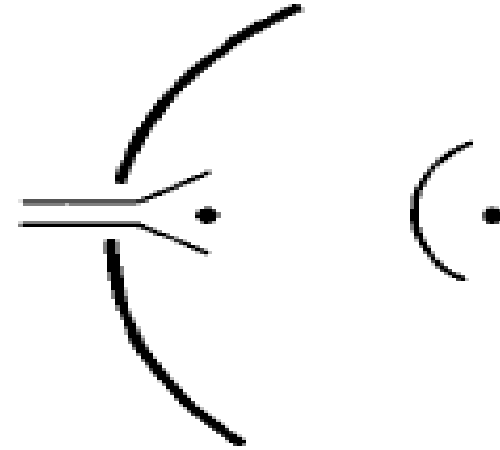
Front Feed



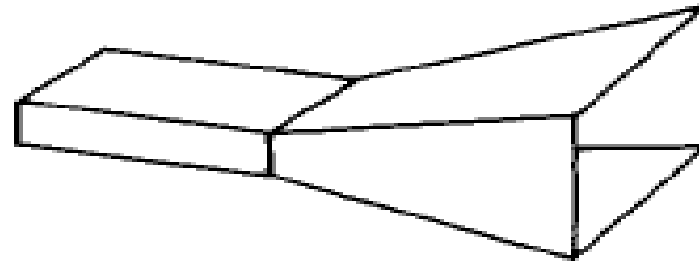
Offset Feed



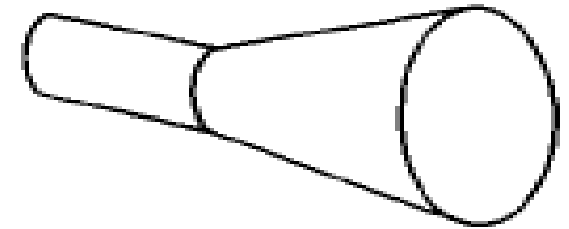
Cassegrain Feed



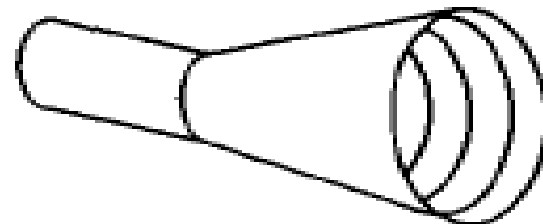
Gregorain Feed



Simple Pyramidal horn



Simple Conical

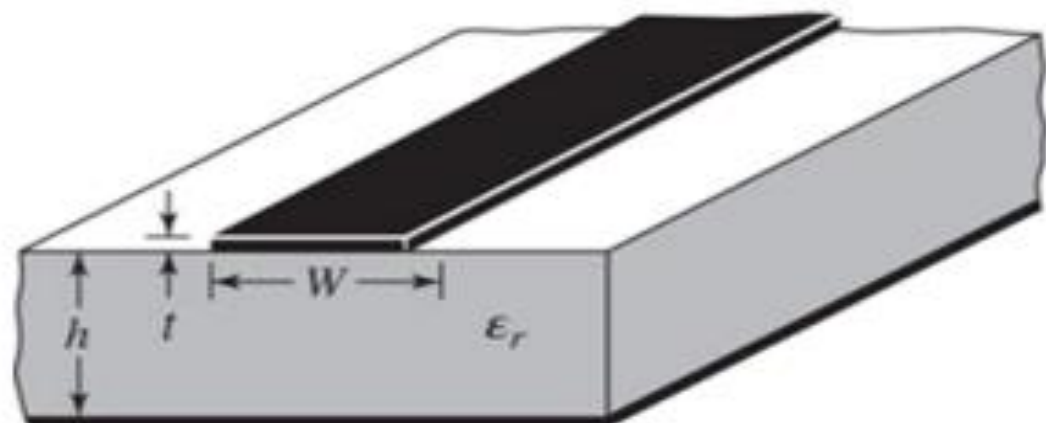


Corrugated Conical Horn

Microstrip Antenna Design

Micro-strip Antenna

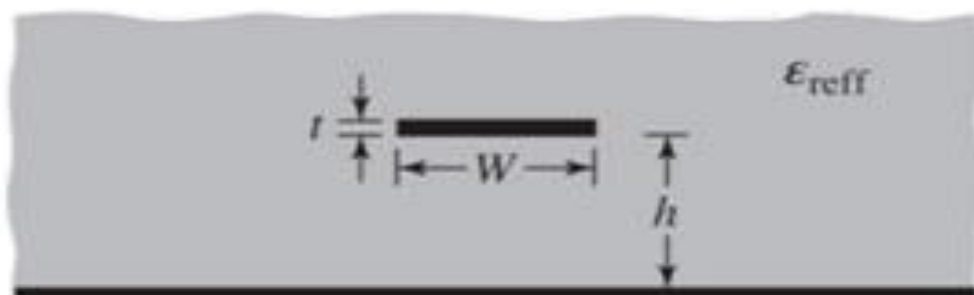
- What is Micro-strip Antenna ?
- A Micro-strip patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side.
- Invented by Bob Munson in 1972 (but earlier work by Dechamps goes back to 1953).



(a) Microstrip line



(b) Electric field lines



(c) Effective dielectric constant

Rectangular Microstrip Feedline formul

Effective Width and Height

$$W = w + \frac{t}{\pi} \left[\ln \left(\frac{2h}{t} \right) + 1 \right]$$

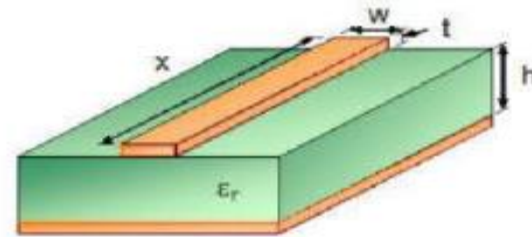
$$H = h - 2t$$

$$\lambda = \frac{c}{f \sqrt{\epsilon_{eff}}}$$

Wavelength

$$\theta = \frac{2\pi}{\lambda}$$

Phase



for $\frac{W}{H} < 1$

$$\epsilon_{eff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[\frac{1}{\sqrt{1 + 12 \frac{H}{W}}} + 0.04 \left(1 - \frac{W}{H} \right)^2 \right]$$

$$Z_0 = \frac{60}{\sqrt{\epsilon_{eff}}} \ln \left(\frac{8H}{W} + \frac{W}{4H} \right) \quad \Omega$$

for $\frac{W}{H} \geq 1$

$$\epsilon_{eff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2 \sqrt{1 + 12 \frac{H}{W}}}$$

$$Z_0 = \frac{120 \pi}{\sqrt{\epsilon_{eff}} \left[\frac{W}{H} + 1.393 + \frac{2}{3} \ln \left(\frac{W}{H} + 1.444 \right) \right]} \quad \Omega$$

The characteristic impedance of the microstrip may be written as

$$Z_o = \begin{cases} \frac{60}{\sqrt{\epsilon_e}} \ln\left(\frac{8d}{W} + \frac{W}{4d}\right) & W/d \leq 1 \\ \frac{120\pi}{\sqrt{\epsilon_e} [W/d + 1.393 + 0.667 \ln(W/d + 1.444)]} & W/d \geq 1 \end{cases}$$

Solving this equation for W/d yields

$$\frac{W}{d} = \begin{cases} \frac{8e^A}{e^{2A} - 2} & W/d \leq 2 \\ \frac{2}{\pi} \left[B - 1 - \ln(2B - 1) + \frac{\epsilon_r - 1}{2\epsilon_r} \left\{ \ln(B - 1) + 0.39 - \frac{0.61}{\epsilon_r} \right\} \right] & W/d \geq 2 \end{cases}$$

where

$$A = \frac{Z_o}{60} \sqrt{\frac{\epsilon_r + 1}{2}} + \frac{\epsilon_r - 1}{\epsilon_r + 1} \left(0.23 + \frac{0.11}{\epsilon_r} \right)$$

$$B = \frac{377\pi}{2Z_o\sqrt{\epsilon_r}}$$

Microstrip Antenna Applications

- Used in mobile satellite communication system.
- Direct broad cast television(DBS).
- Wire less LAN'S.
- Feed elements in coaxial system
- GPS system.
- Missiles and telemetry
- UHF Patch Antennas for Space

Why we use Microstrip Patch Antennas ?

- Flat surface makes them ideal for mounting on airplane
- Impedance matching fairly simple
- Microstrip patch antennas have a very high antenna quality factor(Q).
- Q represents the losses associated with the antenna and a large Q leads to narrow bandwidth and low efficiency.
- Q can be reduced by increasing the thickness of the dielectric substrate. But as the thickness increases, an increasing fraction of the total power delivered by the source goes into a surface wave
- UHF Patch antenna
- UHF Patch Antennas for Space
- These antennas are capable of supporting high data rates to at least 10 Watts of transmitted power.

Shapes of Microstrip Patch



(a) Square



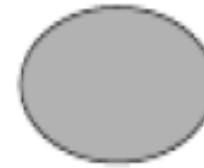
(b) Rectangular



(c) Dipole



(d) Circular



(e) Elliptical



(f) Triangular



(g) Disc sector



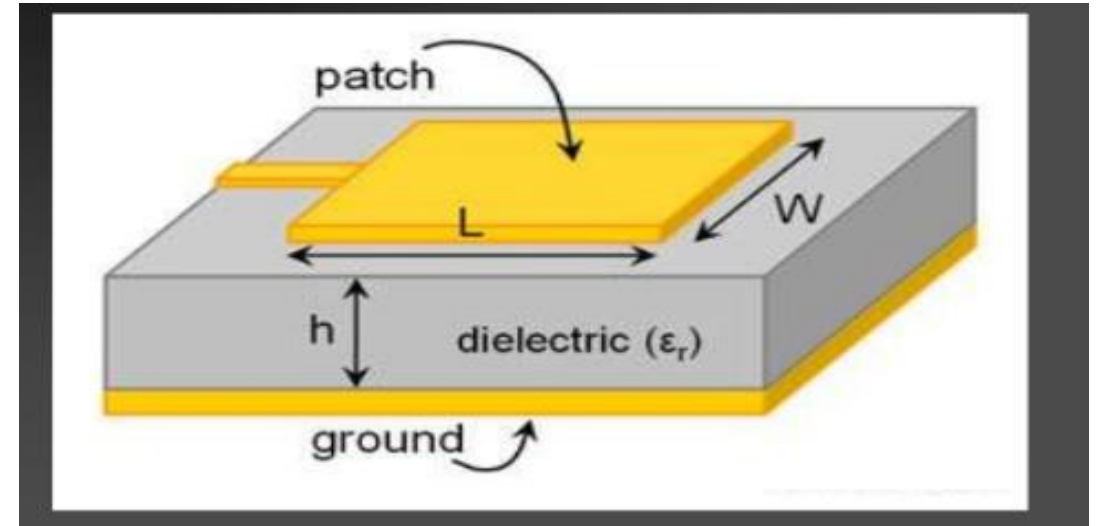
(h) Circular ring



(i) Ring sector

Feeding Techniques

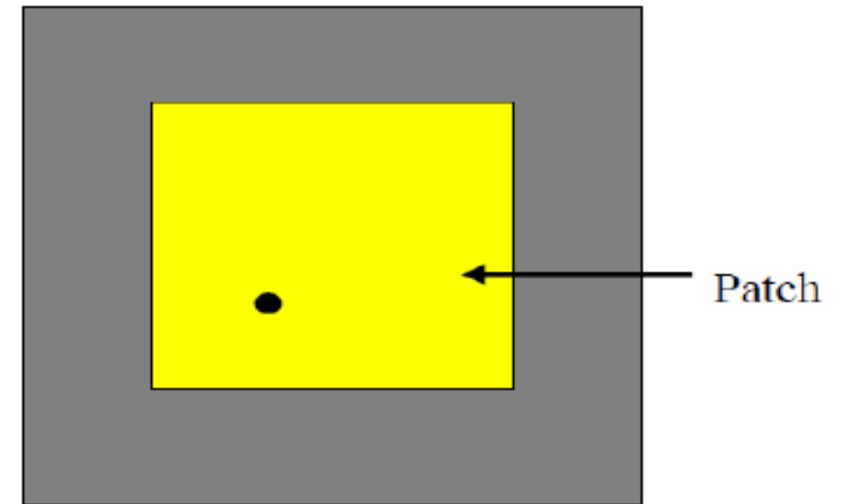
- Coaxial feed
- Microstrip feed
- Proximity coupled microstrip feed
- Aperture coupled microstrip feed
- Coplanar wave guide
- Line Feed



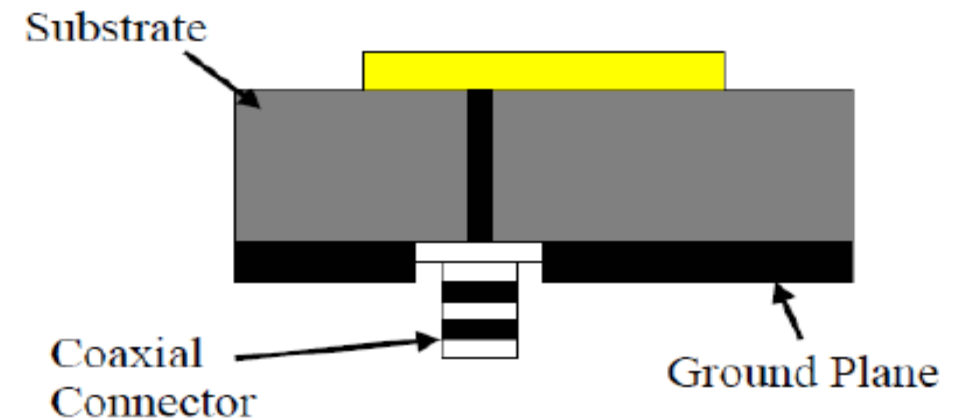
1-Microstrip Line Feed : In this type of feed technique, a conducting strip is connected directly to the edge of the microstrip patch. This kind of feed arrangement has the advantage that the feed can be etched on the same substrate to provide a planar structure.

2-Coaxial Feed

- The Coaxial feed or probe feed is a very common technique used for feeding Microstrip patch antennas.
- The main advantage of this type of feeding scheme is that the feed can be placed at any desired location inside the patch in order to match with its input impedance.
- This feed method is easy to fabricate and has low spurious radiation.
- However, its major disadvantage is that it Coaxia Ground Plane Connector Substrate Patch provides narrow bandwidth and is difficult to model since a hole has to be drilled in the substrate . and the connector protrudes outside the ground plane, thus not making it completely planar for thick substrates .



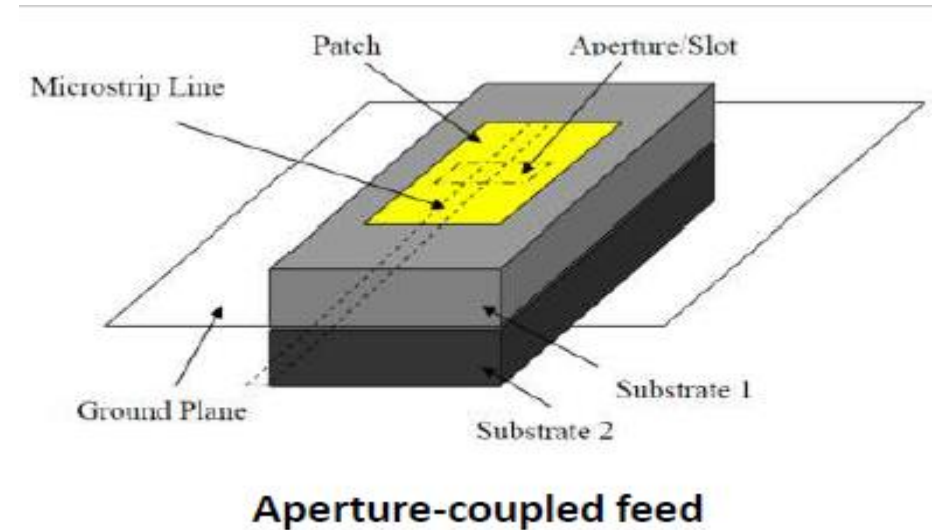
Probe fed Rectangular Microstrip Patch Antenna from top



Probe fed Rectangular Microstrip Patch Antenna from side view

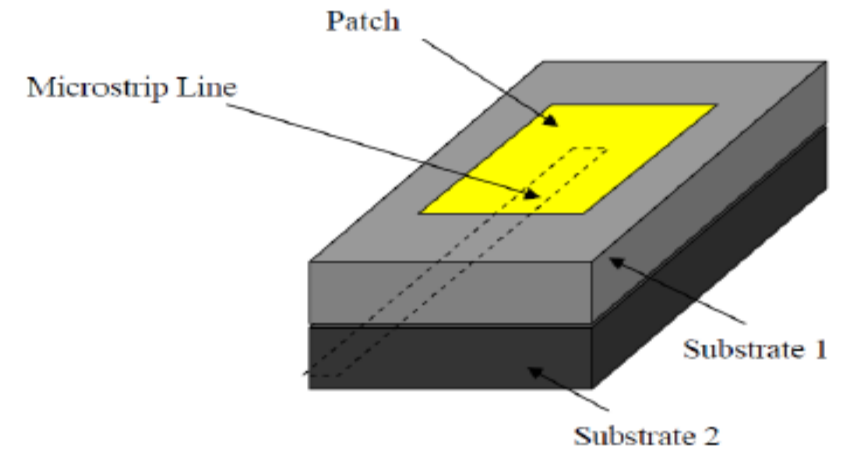
3-Aperture Coupled Feed

- In this type of feed technique, the radiating patch and the microstrip feed line are separated by the ground plane .
- Coupling between the patch and the feed line is made through a slot or an aperture in the ground plane.
- The coupling aperture is usually centered under the patch, leading to lower cross polarization due to symmetry of the configuration.
- The amount of coupling from the feed line to the patch is determined by the shape, size and location of the aperture.



4-Proximity Coupled Feed

- This type of feed technique is also called as “the electromagnetic coupling scheme” .
- The main advantage of this feed technique is that it eliminates spurious feed radiation and provides very high bandwidth due to overall increase in the thickness of the microstrip patch antenna.
- This scheme also provides choices between two different dielectric media, one for the patch and one for the feed line to optimize the individual performances.
- Matching can be achieved by controlling the length of the feed line and the width-to-line ratio of the patch.
- The major disadvantage of this feed scheme is that it is difficult to fabricate because of the two dielectric layers which need proper alignment.
- Also, there is an increase in the overall thickness of the antenna.



Proximity-coupled Feed

Advantages

- Low fabrication cost, hence can be manufactured in large quantities.
- Easily integrated with microwave integrated circuits (MICs).
- Capable of dual and triple frequency operations.
- Supports both, linear as well as circular polarization.
- Low cost , Less size , Low Mass .
- Mechanically robust when mounted on rigid surfaces.
- High Performance
- Light weight and low volume.

Disadvantages

- Narrow bandwidth associated with tolerance problem
- Lower Gain(Nearly 6db) .
- Large ohmic losses in feed structure of arrays.
- Excitation of surface waves .
- Most microstrip antennas radiate into half-space .
- Relatively low efficiency (due to dielectric and conductor losses) .
- relatively high level of cross polarization radiation
- Spurious feed radiation (surface waves, strips, etc.)
- Inherently low impedance bandwidth.
- Low efficiency .
- Extraneous radiation from feeds and junctions .
- Low power handling capacity.

Remedies

- Low power and low gain can overcome by arrays configuration.
- Surface wave associated limitations such as poor efficiency, increased mutual coupling, reduced gain and radiation pattern can overcome.
- The band width can increase up to 60% by using some special techniques.
- In addition, as the substrate thickness increases, the radiation Q of the antenna decreases.
- Thus, impedance bandwidth increases with increasing substrate thickness.

Optimizing the Substrate Properties for Increased Bandwidth

The easiest way to increase the bandwidth of an MSA is to :

1) Print the antenna on a thicker substrate.

- However, thick substrates tend to trap surface wave modes , especially if the dielectric constant of the substrate is high .
- Finally if the substrate is very thick, radiating modes higher than the fundamental will be excited.

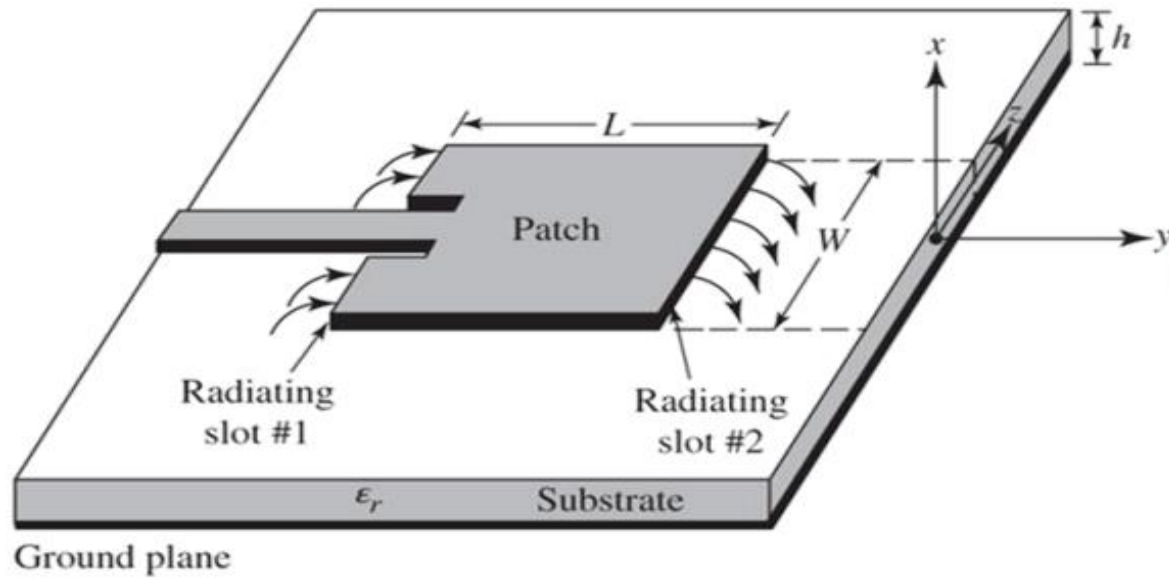
2) Decrease the dielectric constant of the substrate.

- However, this has detrimental effects on antenna size reduction since the resonant length of an MSA is shorter for higher substrate dielectric constant..
- In addition, the directivity of the MSA depends on the dielectric constant of the substrate.

3) Stack two patches on top of each other separated by a dielectric substrate or spacers.

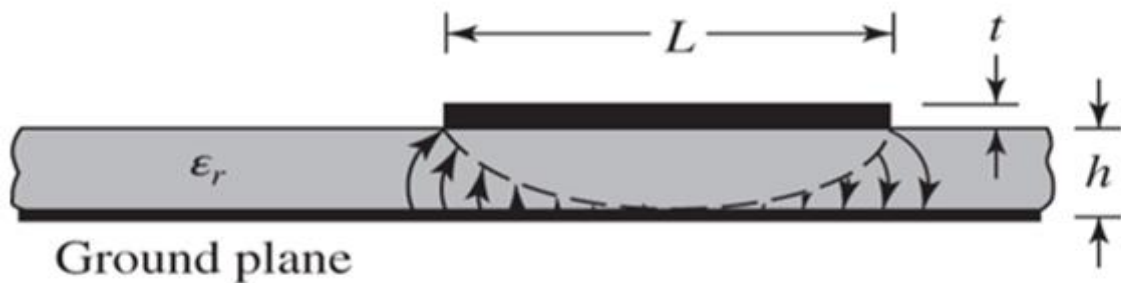
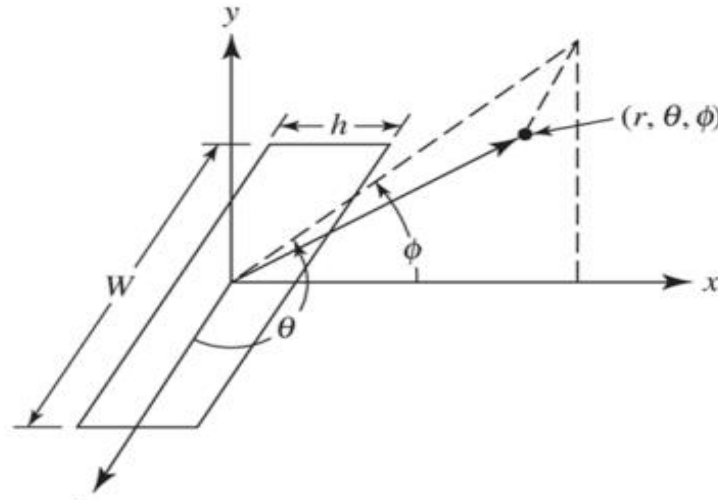
- The application involved two identical circular patches stacked on top of each other. The lower patch was fed using a coaxial probe feed, and the top patch was electromagnetically coupled to the lower one .

Rectangular Microstrip Antenna



$\frac{\lambda_0}{3} < L < \frac{\lambda_0}{2}$
 $2.2 \leq \epsilon_r \leq 12$
 W is tuned to get
 desired impedance
Coordinate System For
 Each Radiating Slot

- Easy to fabricate
- Simple to match
- Low spurious radiation
- Narrow bandwidth
- Good for low h



$t \ll \lambda_0$
 $h \ll \lambda_0$
 $(0.003\lambda_0 \leq h \leq 0.05\lambda_0)$

Design of MSA patch length and width

Step 1: Calculation of the Width (W) -

$$W = \frac{c}{2f_0 \sqrt{\frac{(\epsilon_r + 1)}{2}}}$$

Step 2: Calculation of the Effective Dielectric Constant. This is based on the height, dielectric constant of the dielectric and the calculated width of the patch antenna.

$$\epsilon_{eff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[1 + 12 \frac{h}{W} \right]^{-\frac{1}{2}}$$

Step 3: Calculation of the Effective length

$$L_{eff} = \frac{c}{2f_0 \sqrt{\epsilon_{eff}}}$$

$$\text{Length of Patch (L)} = L_{eff} - 2\Delta L$$

$$\text{Length of Substrate (L}_g) = 6h + L$$

$$\text{Width of Substrate (W}_g) = 6h + W$$

Step 4: Calculation of the length extension ΔL

$$\Delta L = 0.412h \frac{(\epsilon_{eff} + 0.3) \left(\frac{W}{h} + 0.264 \right)}{(\epsilon_{eff} - 0.258) \left(\frac{W}{h} + 0.8 \right)}$$

Step 5: Calculation of actual length of the patch

$$L = L_{eff} - 2\Delta L$$

Where the following parameters are used

f_0 is the Resonance Frequency

W is the Width of the Patch

L is the Length of the Patch

h is the thickness

ϵ_r is the relative Permittivity of the dielectric substrate

c is the Speed of light: 3×10^8

Rectangular Patch - Fields

$$f(\theta, \phi) = \frac{\sin \left[\frac{kW}{2} \sin(\theta) \sin(\phi) \right]}{\frac{kW}{2} \sin(\theta) \sin(\phi)} \cos \left(\frac{kL}{2} \sin(\theta) \cos(\phi) \right)$$

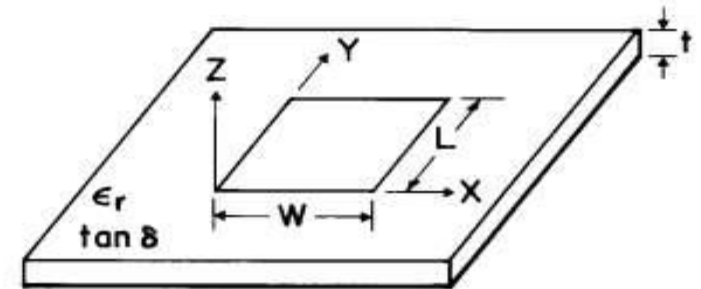
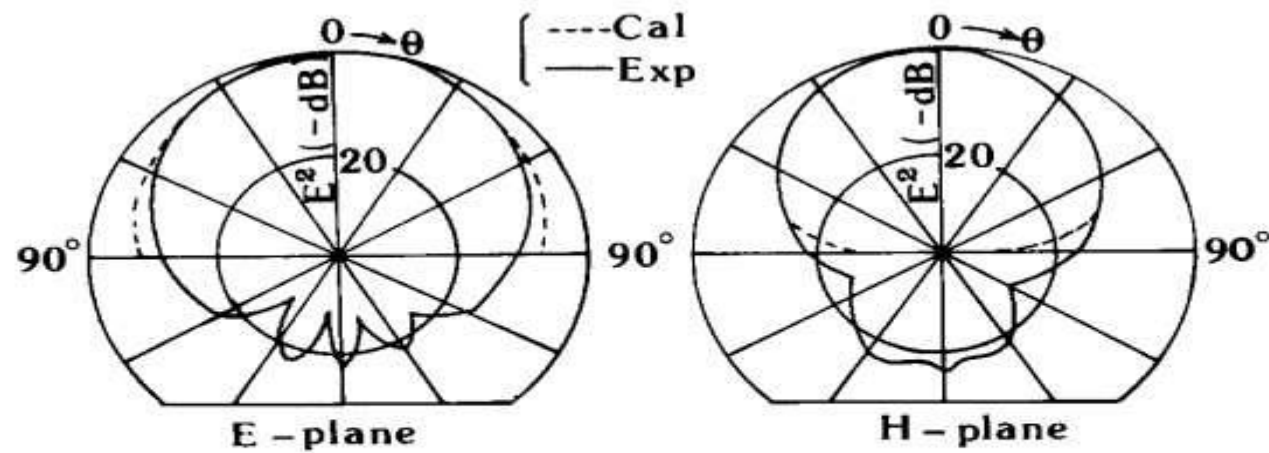
$$F_E(\theta) = \cos \left(\frac{kL}{2} \sin(\theta) \right), \quad \phi = 0^\circ$$

$$F_H(\theta) = \cos(\theta) \frac{\sin \left(\frac{kW}{2} \sin(\theta) \right)}{\frac{kW}{2} \sin(\theta)}, \quad \phi = 90^\circ$$

An approximate expression of the bandwidth for $VSWR \leq 2$, $|\Gamma| \leq \frac{1}{3}$,

$$BW = 3.771 \left[\frac{\epsilon_r - 1}{(\epsilon_r)^2} \right] \frac{h}{\lambda_0} \left(\frac{W}{L} \right)$$

Radiation patterns of a rectangular microstrip patch antenna



Example

Design a rectangular microstrip antenna using a substrate (RT/duroid 5880) with dielectric constant of 2.2, $h = 0.1588$ cm (0.0625 inches) so as to resonate at 10 GHz.

Solution: Using (14-6), the width W of the patch is

$$W = \frac{30}{2(10)} \sqrt{\frac{2}{2.2 + 1}} = 1.186 \text{ cm (0.467 in)}$$

The effective dielectric constant of the patch is found using (14-1), or

$$\epsilon_{\text{reff}} = \frac{2.2 + 1}{2} + \frac{2.2 - 1}{2} \left(1 + 12 \frac{0.1588}{1.186} \right)^{-1/2} = 1.972$$

The extended incremental length of the patch ΔL is, using (14-2)

$$\begin{aligned} \Delta L &= 0.1588(0.412) \frac{(1.972 + 0.3) \left(\frac{1.186}{0.1588} + 0.264 \right)}{(1.972 - 0.258) \left(\frac{1.186}{0.1588} + 0.8 \right)} \\ &= 0.081 \text{ cm (0.032 in)} \end{aligned}$$

The actual length L of the patch is found using (14-3), or

$$L = \frac{\lambda}{2} - 2\Delta L = \frac{30}{2(10)\sqrt{1.972}} - 2(0.081) = 0.906 \text{ cm (0.357 in)}$$

Finally the effective length is

$$L_e = L + 2\Delta L = \frac{\lambda}{2} = 1.068 \text{ cm (0.421 in)}$$

An experimental rectangular patch based on this design was built and tested. It is probed from underneath by a coaxial line and is shown in Figure 14.8(a). Its principal E - and H -plane patterns are displayed in Figure 14.19(a,b).

Örnek: Design microstrip antenna $f_0=1.85\text{GHz}$

$$W = \frac{c}{2f_0 \sqrt{\frac{(\epsilon_r + 1)}{2}}}$$

$$\epsilon_{r_{eff}} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[1 + 12 \frac{h}{W} \right]^{-\frac{1}{2}}$$

$$\Delta L = 0.412h \frac{(\epsilon_{r_{eff}} + 0.3) \left(\frac{W}{h} + 0.264 \right)}{(\epsilon_{r_{eff}} - 0.258) \left(\frac{W}{h} + 0.8 \right)}$$

$c = 3 \times 10^8 \text{ m/sec}$
 $\epsilon_r = 11.9$
 $f_0 = 1.85 \text{ GHz}$
 Therefore,
 $W = 31.9 \text{ mm} = 0.0319 \text{ m}$

$\epsilon_r = 11.9$
 $h = 1.59 \text{ mm}$
 $W = 31.9 \text{ mm}$
 Therefore,
 $\epsilon_{r_{eff}}$ is equal to 10.7611

$\epsilon_r = 11.9$
 $h = 1.59 \text{ mm}$
 $W = 31.9 \text{ mm}$
 Therefore,
 The value of ΔL is $6.72 \times 10^{-1} \text{ mm}$

The effective length of the patch L_{eff} now becomes:

$$L_{eff} = L + 2\Delta L$$

For a given resonance frequency f_0 , the effective length is given by as:

$$L_{eff} = \frac{c}{2f_0 \sqrt{\epsilon_{r_{eff}}}}$$

$$\epsilon_{r_{eff}} = 10.7611$$

therefore, the value of L_{eff} is 24.7 mm & value of L will be 23.36 mm.

Örnek: Design microstrip antenna fo=3GHz

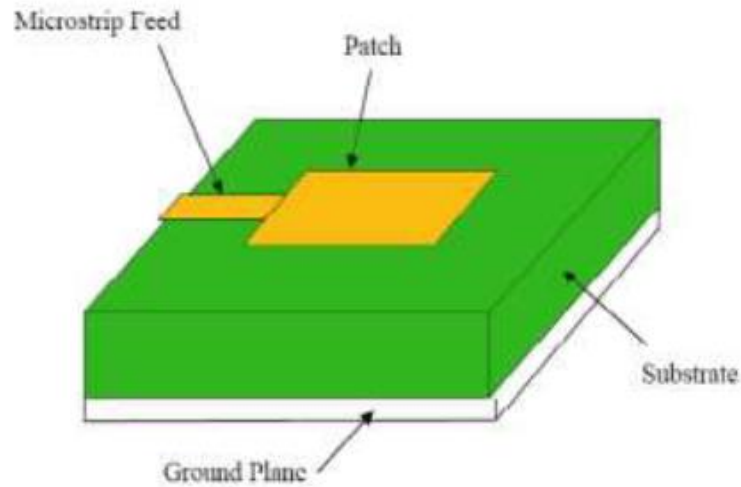


Figure -Structure of the patch

$$W = \frac{c}{2f_r} \sqrt{\frac{2}{\epsilon_r + 1}} \quad (1)$$

$$= \frac{(3 \times 10^8)}{2(3G)} \sqrt{\frac{2}{(2.33) + 1}}$$

$$= 38.749 \text{ mm}$$

$$= 0.03874 \text{ m}$$

$$\epsilon_{reff} = \left(\frac{\epsilon_r + 1}{2}\right) + \left(\frac{\epsilon_r - 1}{2}\right) \left[1 + 12 \frac{h}{W}\right]^{-\frac{1}{2}}$$

$$= \left[\frac{(2.33) + 1}{2}\right] + \left[\frac{(2.33) - 1}{2}\right] \times$$

$$\left[1 + 12 \frac{(0.508 \times 10^{-3})}{(38.749 \times 10^{-3})}\right]^{-\frac{1}{2}} = 1.665 + 0.665(1.1573)^{-\frac{1}{2}} = 2.2832$$

$$\lambda = 0.1 \text{ m} = 100 \text{ mm}$$

$$\text{GND dimension: } \lambda$$

$$\Delta L = 0.412h \left[\frac{(\epsilon_{reff} + 0.3) \left(\frac{W}{h} + 0.264\right)}{(\epsilon_{reff} - 0.258) \left(\frac{W}{h} + 0.8\right)} \right]$$

$$= 0.412(0.508 \times 10^{-3}) \times$$

$$\left\{ \frac{[(2.2832) + 0.3] \left[\frac{(38.749 \times 10^{-3})}{(0.508 \times 10^{-3})} + 0.264 \right]}{[(2.2832) - 0.258] \left[\frac{(38.749 \times 10^{-3})}{(0.508 \times 10^{-3})} + 0.8 \right]} \right\}$$

$$= \frac{0.04138}{156.0975} = 0.2651 \text{ mm}$$

$$\lambda_g = \frac{c}{f \sqrt{\epsilon_{reff}}} = \frac{(3 \times 10^8)}{(3G) \sqrt{(2.2832)}} = 0.0662$$

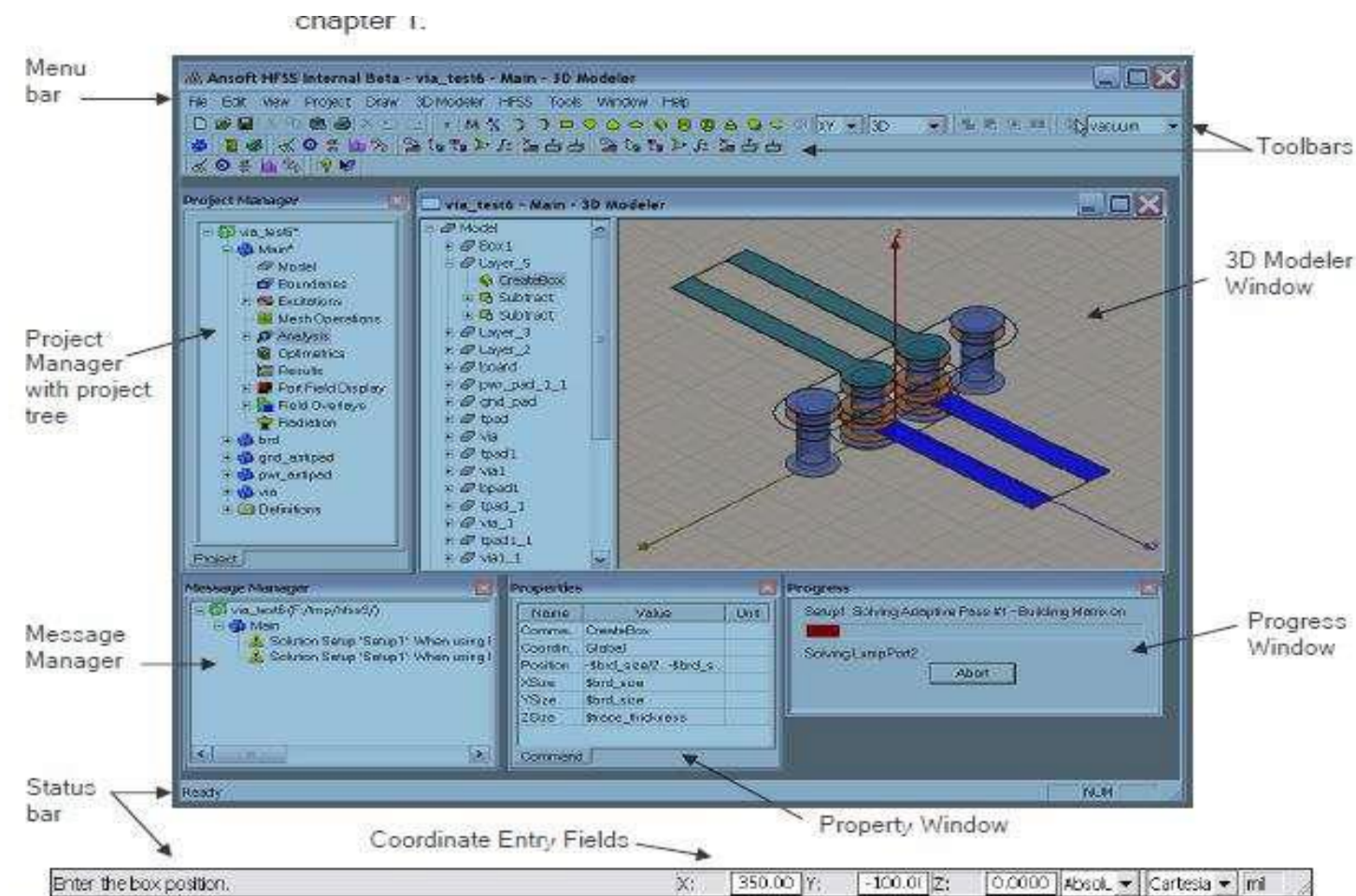
$$L = \frac{\lambda_g}{2} - 2\Delta L = \frac{(0.0662)}{2} - 2(0.2651 \times 10^{-3})$$

$$= 0.03257 = 32.57 \text{ mm} \approx 33 \text{ mm}$$

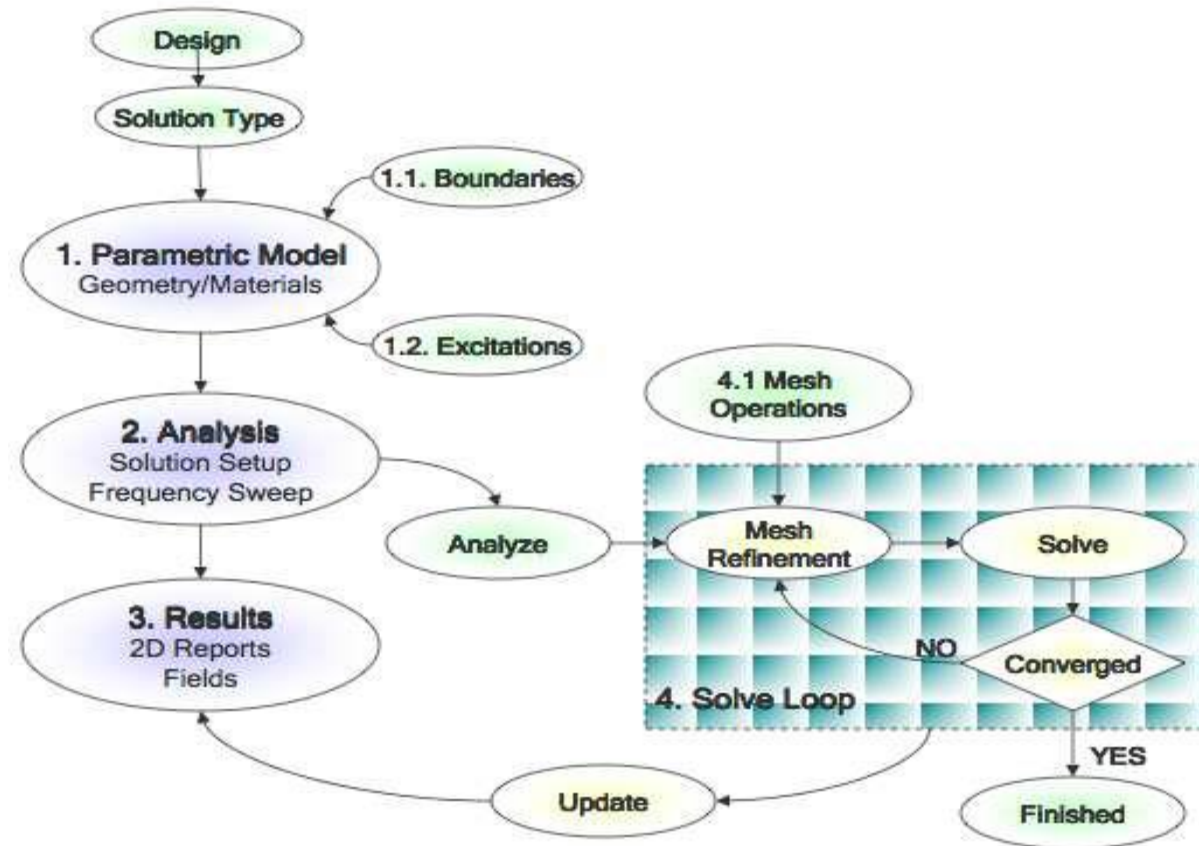
*Designing
Microstrip Patch Antenna
by Using HFSS*

Designing the Microstrip patch

- HFSS stands for high frequency structure simulator
- ANSYS HFSS software is the industry standard for simulating 3-D full wave electromagnetic fields.



Designing the Microstrip patch



Design specification of rectangular patch antenna

3D model

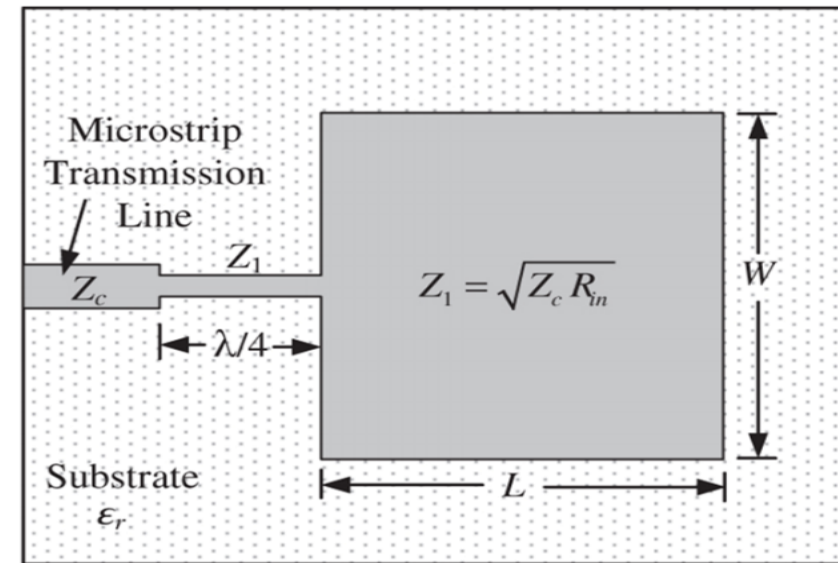
- Ground: W_g, L_g
- Substrate: W_g, L_g, h, ϵ_r
- Microstrip line(feed): W_f, L_f
- Radiated Patch: W, L
- Lumped Port: 1mm
- Radiation measure wall: R

Tüm uzunluklar dalga boyunun katsayı çarpımı ile ifade edilir.

Assigning boundary: Perfect E

Assigning excitation: Lumped Port, Radiation

Matching Techniques



$\lambda/4$ impedance transformer

Analysis of patch antenna

Analysis setup

- solution freq
- max number of passes
- max Delta S per pass

Freq sweep

- starting freq
- attenuating freq
- number of counting

Analyze

Örnek: Design microstrip antenna

$f_0=2.4\text{GHz}$, $\epsilon_r=4.4$, $h=1.5\text{mm}$

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{2.4 \times 10^9} = 0.125\text{m} = 125\text{mm}$$

Length of Ground Plane, $L_g = \lambda$

$$W = \frac{\lambda/2}{\sqrt{\frac{\epsilon_r+1}{2}}} = 0.038\text{m} = 38\text{mm}$$

Width of Ground Plane, $W_g = \lambda$

$$L = L_{eff} - 2\Delta L = 29\text{mm}$$

$$\epsilon_{eff} = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2} \left[1 + \frac{12h}{W} \right]^{-\frac{1}{2}} = 4.24$$

$$\lambda_g = \frac{\lambda}{\sqrt{\epsilon_{eff}}} = 60\text{mm}$$

$$L_{eff} = \frac{\lambda/2}{\sqrt{\epsilon_{eff}}} = 30.34\text{mm}$$

Length of Substrate, $L_s = L + \lambda_g/2 = 59\text{mm}$

$$\Delta L = 0.412h \frac{(\epsilon_{eff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\epsilon_{eff}-0.258)\left(\frac{W}{h}+0.8\right)} = 0.69\text{mm}$$

Width of Substrate, $W_s = W + \lambda_g/4 = 68\text{mm}$

File Edit View Project Draw Modeler HFSS Tools Window Help

Select: Object
Select by Name

Save Cut Copy Paste Undo Redo Delete

Zoom Pan Rotate Orient

Fit All Fit Selected

Move Rotate Mirror Unite Subtract Intersect Split Imprint Fillet Chamfer

Measure Ruler Units

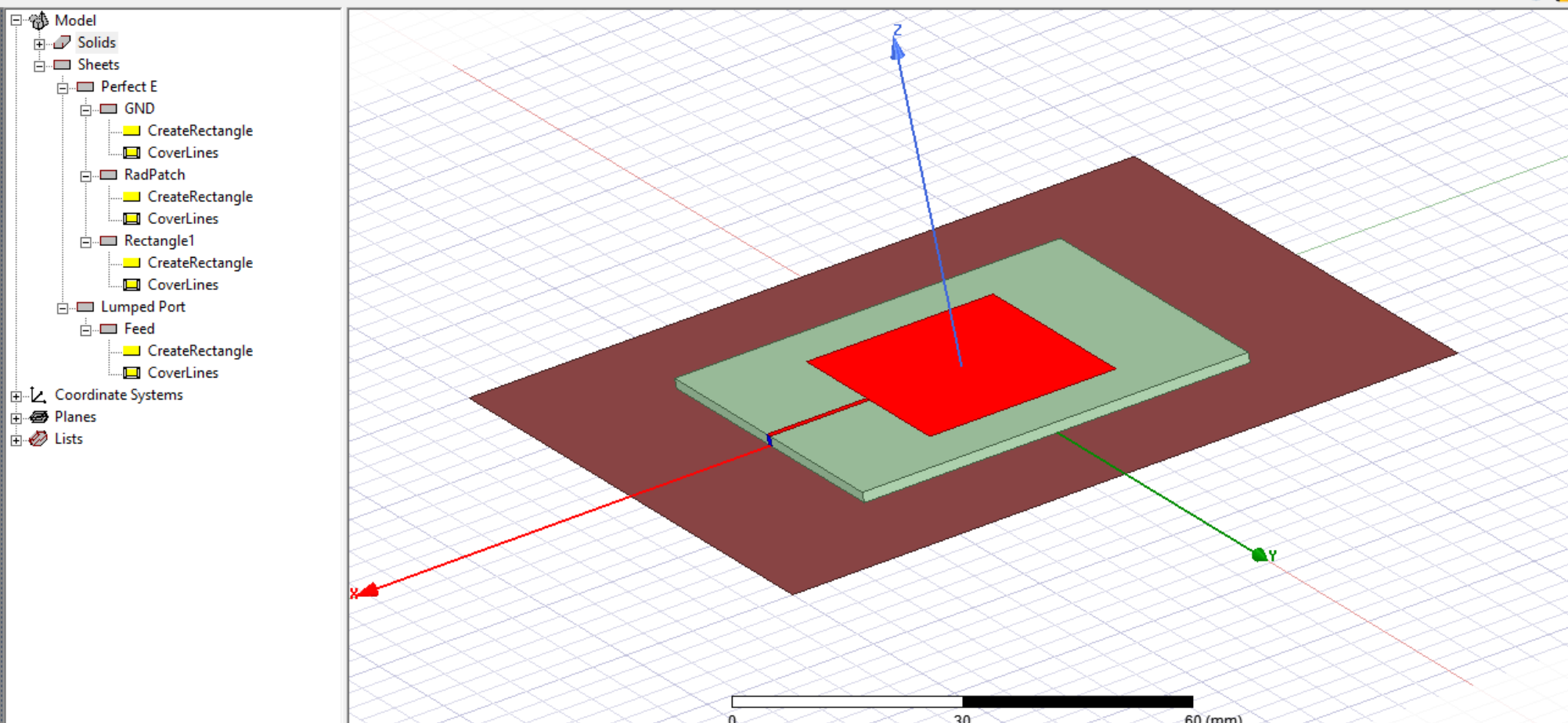
Grid XY 3D

Model vacuum Material

Desktop View Draw Model Simulation Results Automation

Project Manager

- Project1*
- Model
 - Solids
 - Sheets
 - Perfect E
 - GND
 - CreateRectangle
 - CoverLines
 - RadPatch
 - CreateRectangle
 - CoverLines
 - Rectangle1
 - CreateRectangle
 - CoverLines
 - Lumped Port
 - Feed
 - CreateRectangle
 - CoverLines
 - Coordinate Systems
 - Planes
 - Lists



Message Manager Progress

ANSYS Electronics Desktop - Project1

File Edit View Project Tools Window Help

New Open Open Examples Save Save As Close Save Archive Restore Archive Cut Copy Paste Undo Redo Delete HFSS Q3D Circuit Icepak Maxwell Twin Builder Update Definitions Remove Unused Definitions Edit Definitions Project Variables Datasets Event Callbacks General Options Help ANSYS

Desktop View Simulation Automation

Project Manager

Project1
Definitions

Properties

Name	Value	Unit	Evaluated Value



Desktop View Simulation Automation

New Open Open Examples Save Save As Close Save Archive Restore Archive Cut Undo Copy Redo Paste Delete HFSS Q3D Circuit Icepak Maxwell Twin Builder Update Definitions Remove Unused Definitions Edit Definitions Project Variables Datasets Event Callbacks General Options Help ANSYS

Project Manager

Project1*

- Definitions
 - Components
 - Symbols
 - Footprints
 - Padstacks
 - Models
 - Packages
 - Materials
 - Surface Materials
 - Scripts

1

- HFSS
- HFSS 3D Layout
- HFSS-IE
- Launch Savant
- Launch EMIT

2

Properties

Name	Value	Unit	Evaluated Value
------	-------	------	-----------------

Save Cut Copy Paste Undo Redo Delete Select: Object Select by Name Zoom Pan Rotate Orient Fit All Fit Selected Move Rotate Mirror Intersect Unite Subtract Imprint Intersect Fillet Chamfer Measure Ruler Units Grid Model vacuum Material

Project Manager

- Project1*
 - HFSSDesign2 (DrivenModal)
 - Definitions
 - Components
 - Symbols
 - Footprints
 - Padstacks
 - Models
 - Packages
 - Materials
 - Surface Materials
 - Scripts

Coordinate Systems
Planes
Lists

Draw rectangle
Add a rectangle to the model

Set Model Units

Select units: mm

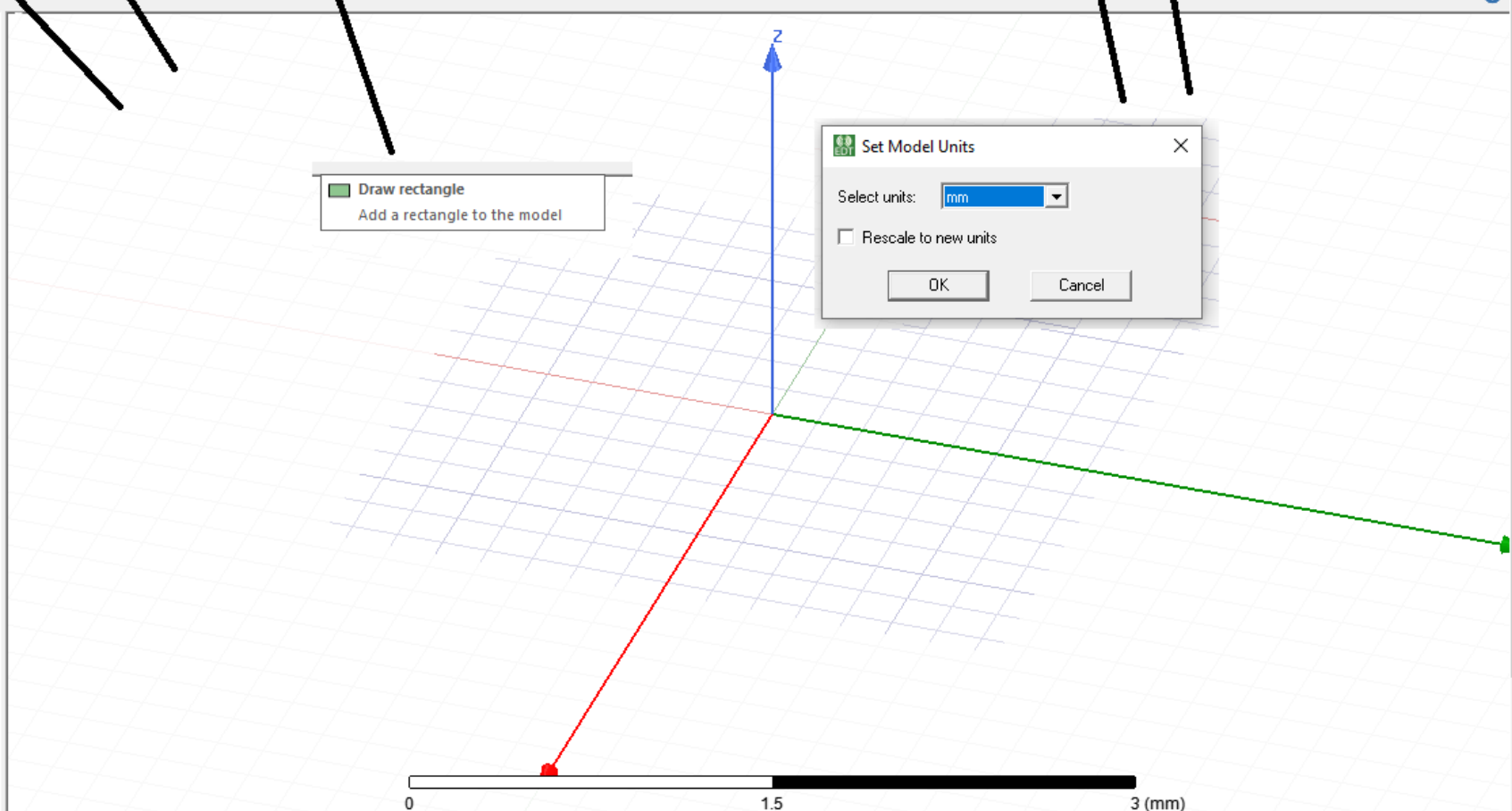
Rescale to new units

OK Cancel

Properties

Name	Value	Unit	Evaluated Value

Variables



GND

Desktop View Draw Model Simulation Results Automation

Project Manager

- 2020-Microstrip*
- HFSSDesign1 (DrivenModal)*
- Definitions

Model

- Solids
 - FR4_epoxy
 - Box1
 - CreateBox
 - vacuum
- Sheets
 - Perfect E
 - GND
 - CreateRectangle
 - CoverLines

Properties: 2020-Microstrip - HFSSDesign1 - Modeler

Command

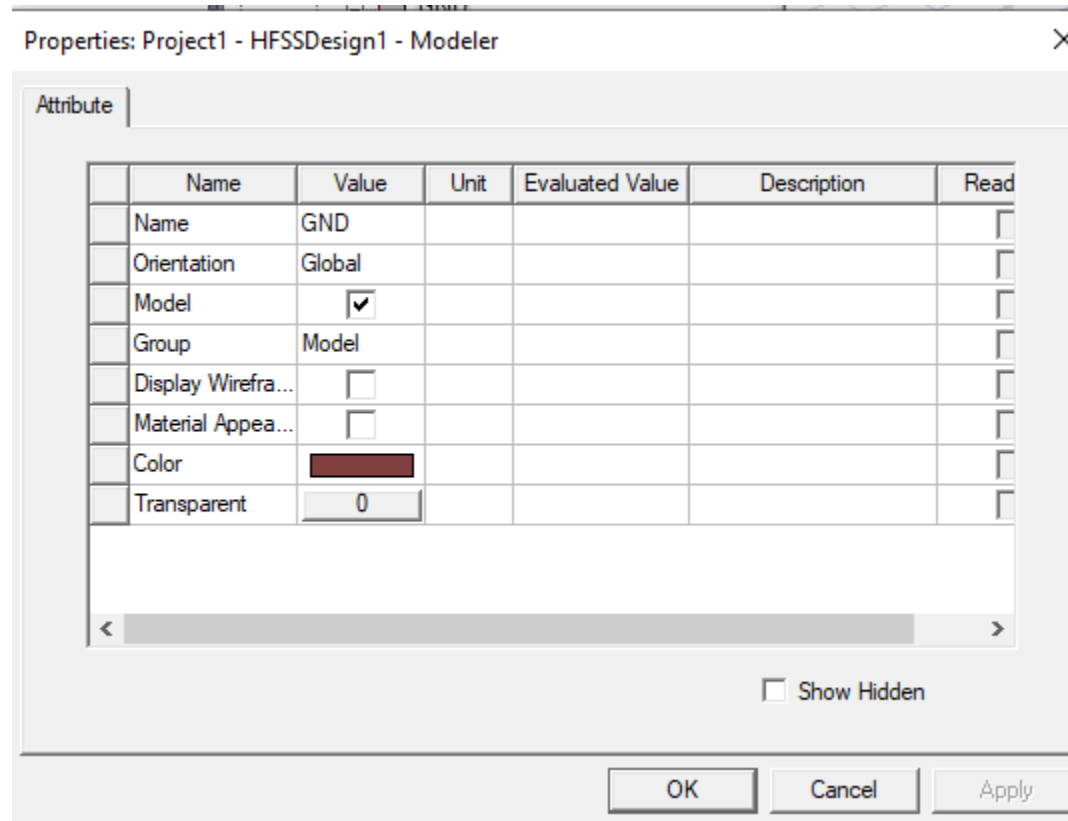
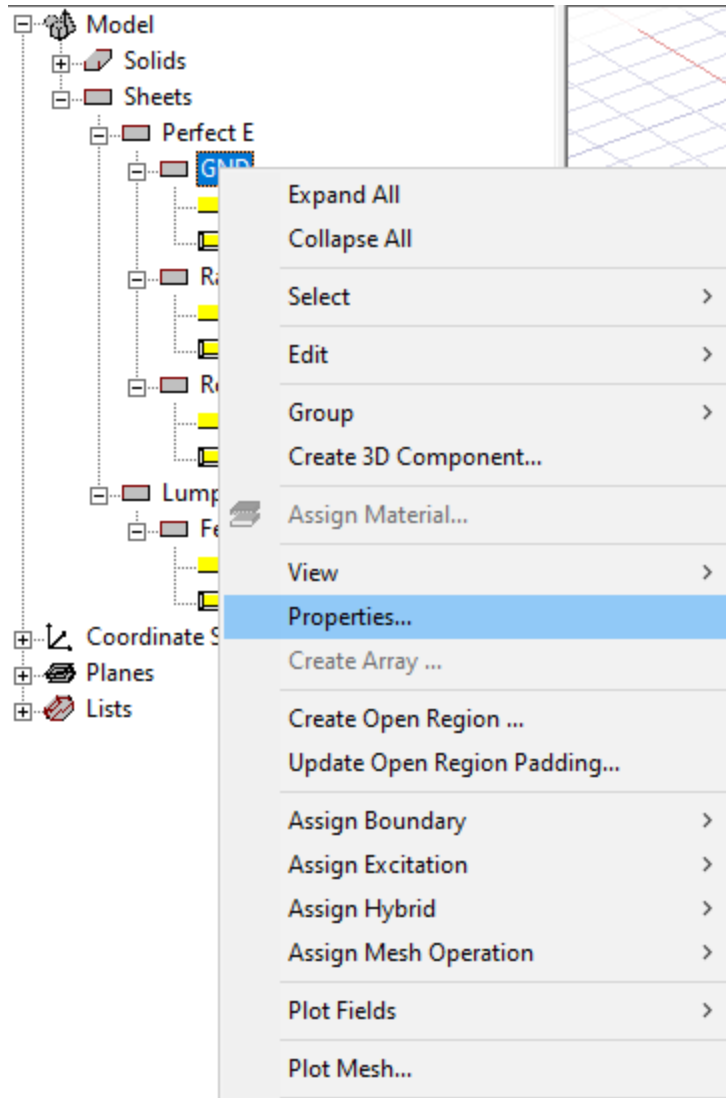
Name	Value	Unit	Evaluated Value	Description
Command	CreateRectangle			
Coordinate Sys...	Global			
Position	-Lg/2, -Wg/2, 0mm		-62.5mm, -62.5mm, 0mm	
Axis	Z			
XSize	Lg		125mm	
YSize	Wg		125mm	

Show Hidden

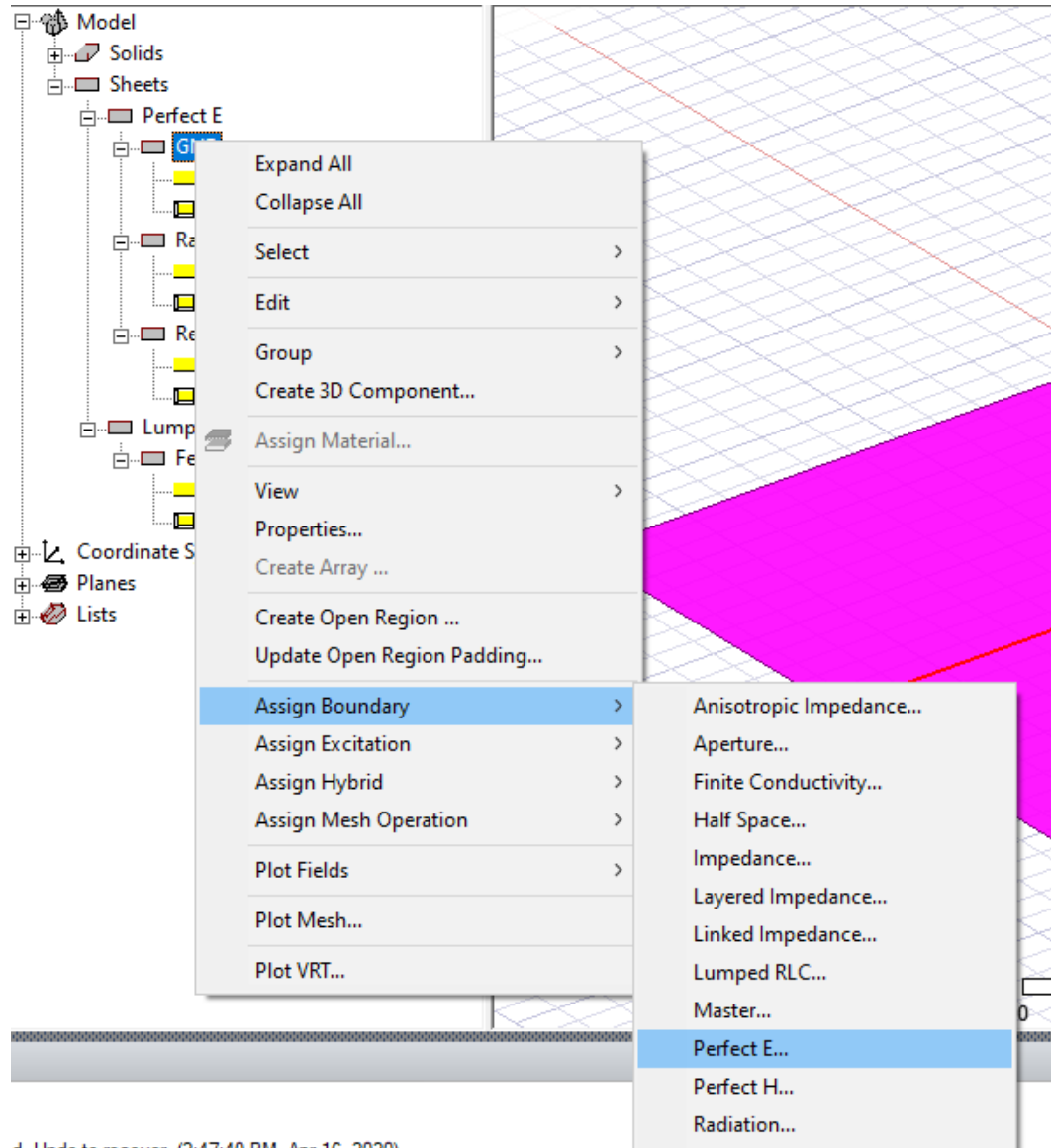
OK Cancel Apply

0 35 70 (mm)

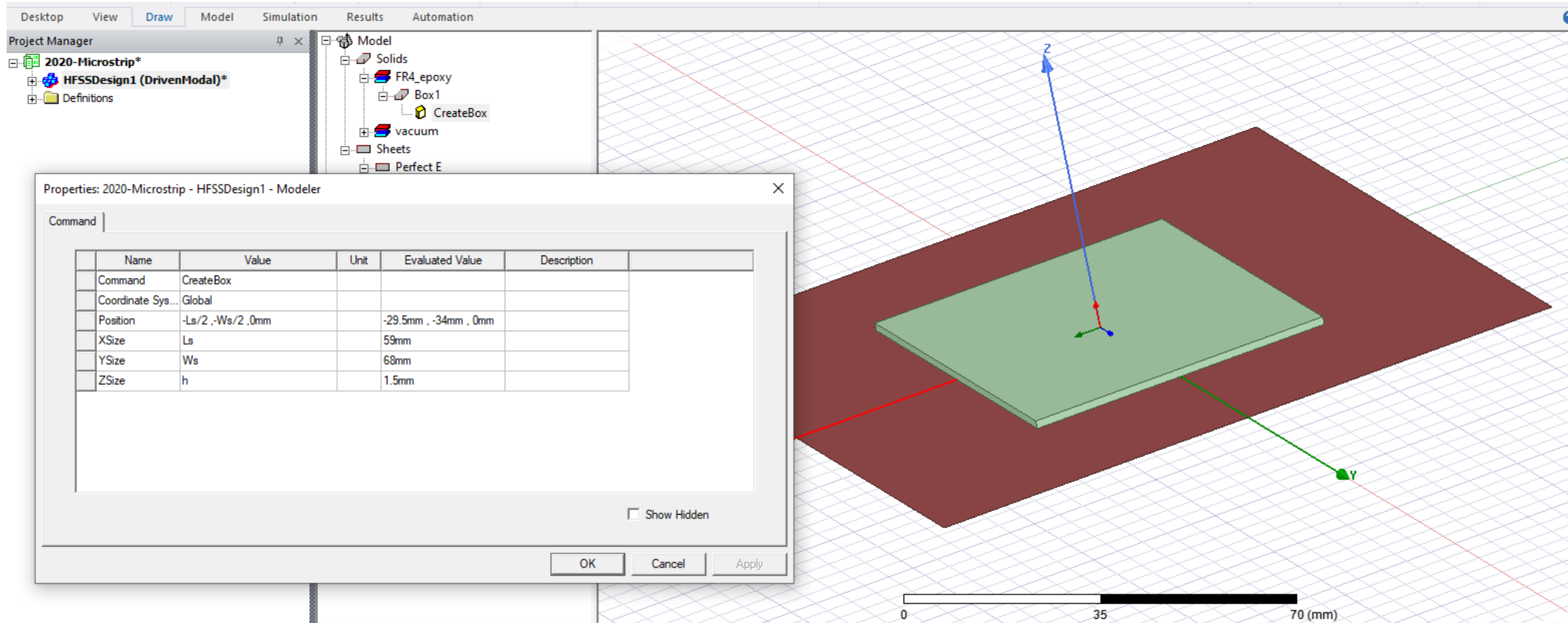
GND – Properties: Name, Color



GND – Properties: Assign Boundary - Perfect E



Substrate



Substrate – Assign material

The screenshot displays the ANSYS Electronics Desktop interface. The main workspace shows a 3D model of a substrate with a pink rectangular region selected. A context menu is open over this region, listing various actions such as 'Assign Material...', 'Properties...', and 'Create Array...'. The Properties panel on the left shows the following details for the selected object:

Name	Value	Unit	Evaluated Value
Name	Box1		
Material	"vacuum"		"vacuum"
Solve Inside	<input checked="" type="checkbox"/>		
Orientation	Global		
Model	<input checked="" type="checkbox"/>		
Group	Model		
Display Wi...	<input type="checkbox"/>		
Material A...	<input type="checkbox"/>		
Color			
Transparent	0		

The bottom of the interface shows a Message Manager with the message 'Assign material' and a Progress bar.

Assign material

Hide 0 Messages Hide Progress

Substrate - Material

ANSYS Electronics Desktop - Project1 - HFSSDesign1 - 3D Modeler - SOLVED - [Project1 - HFSSDesign1 - Modeler]

File Edit View Project Draw Modeler HFSS Tools Window Help

Save Cut Undo Select: Edge Copy Redo Select by Name Paste Delete Zoom Pan Rotate Orient Fit All Fit Selected Move Rotate Mirror Unite Subtract Imprint Fillet Chamfer Measure Ruler Grid XY 3D Model vacuum Material

Desktop View Draw Model Simulation Results Automation

Project Manager

- Project1*
- HFSSDesign1 (DrivenModal)*
 - 3D Components
 - Model
 - Solids
 - FR4_epoxy
 - Box1
 - CreateBox

Select Definition

Materials | Material Filters

Search Parameters
Search by Name

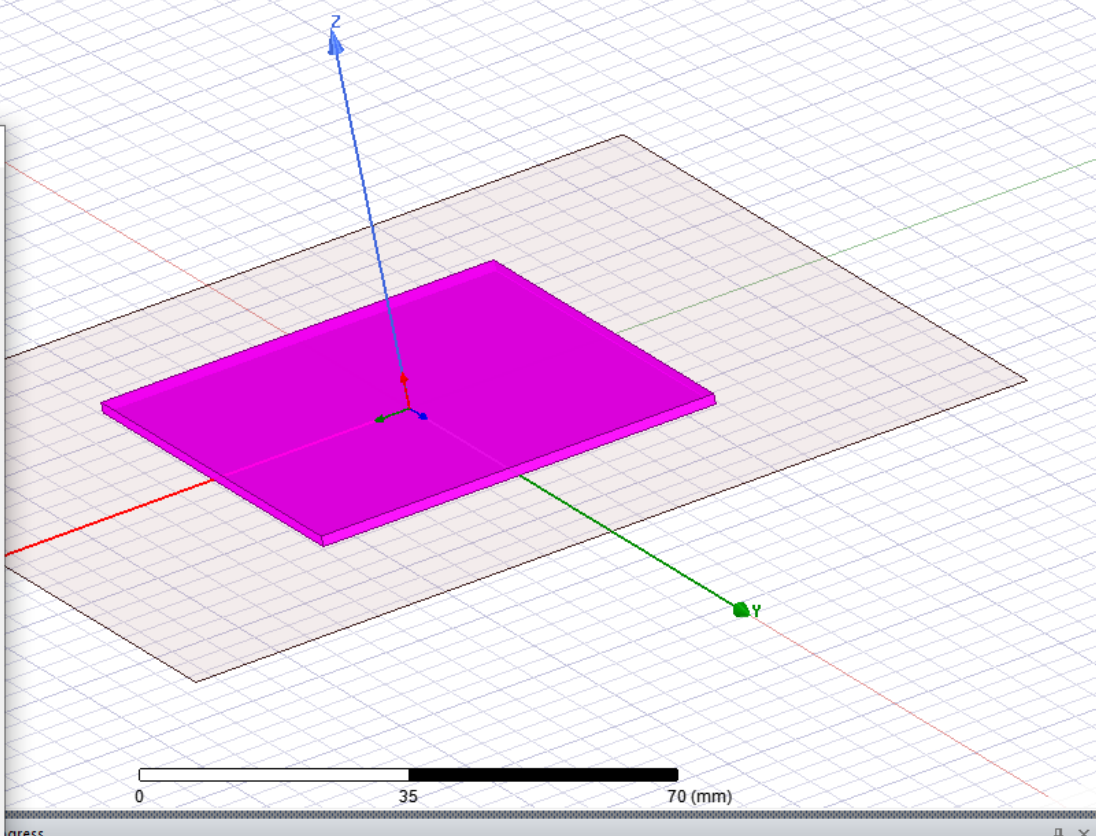
Search Criteria
 by Name by Property

Libraries Show Project definitions Show all libraries

Name	Location	Origin	Relative Permittivity	Relative Permeability	B Cond
FR4_epoxy	Project	Materials	4.4	1	0
FR4_epoxy	SysLibrary	Materials	4.4	1	0
gallium_arsenide	SysLibrary	Materials	12.9	1	0
GE GETEK ML200/RG200 (tm)	SysLibrary	Materials	3.9	1	0
GIL GML1000 (tm)	SysLibrary	Materials	3.12	1	0
GIL GML1032 (tm)	SysLibrary	Materials	3.2	1	0
GIL GML2032 (tm)	SysLibrary	Materials	3.2	1	0
GIL MC5 (tm)	SysLibrary	Materials	3.2	1	0
glass	SysLibrary	Materials	5.5	1	0
glass_PTFEreinf	SysLibrary	Materials	2.5	1	0
gold	SysLibrary	Materials	1	0.99996	41000000sie

View/Edit Materials... Add Material... Clone Material(s) Remove Material(s) Export to Library...

OK Cancel Help



3:13 PM
4/16/2020

Radiated Part

ANSYS Electronics Desktop - Project1 - HFSSDesign1 - 3D Modeler - SOLVED - [Project1 - HFSSDesign1 - Modeler]

File Edit View Project Draw Modeler HFSS Tools Window Help

Save Cut Copy Paste Undo Redo Delete Select: Edge Select by Name Zoom Pan Rotate Orient Fit All Fit Selected Move Rotate Mirror Unite Subtract Imprint Intersect Fillet Chamfer Measure Ruler Units Grid Model vacuum Material

Desktop View Draw Model Simulation Results Automation

Project Manager

- Project1*
- HFSSDesign1 (DrivenModal)*
 - 3D Components
 - Model
 - Circuit Elements
 - Boundaries
 - Excitations
 - Hybrid Regions
 - Mesh Operations
 - Analysis
 - Optimetrics
 - Results
 - S Parameters
 - Gain Plot
 - Port Field Display
 - Field Overlays
 - Radiation
 - Definitions

Model

- Solids
 - FR4_epoxy
 - Box1
 - CreateBox
 - vacuum
 - Sheets
 - Perfect E
 - GND
 - CreateRectangle
 - CoverLines
 - RadPatch
 - CreateRectangle

Properties: Project1 - HFSSDesign1 - Modeler

Command

Name	Value	Unit	Evaluated Value
Command	CreateRectangle		
Coordinate Sys...	Global		
Position	-L/2, -W/2, h		-14.5mm, -19mm, 1.5mm
Axis	Z		
XSize	L		29mm
YSize	W		38mm

OK Cancel Apply

Message Manager

- Interpolat
- Normal co
- HFSSDes
- Adaptive

Nothing is selected

Progress

0 35 70 (mm)

Hide 10 Messages Hide Progress

3:15 PM 4/16/2020

Radiated Part – Properties (Name, Color)

The screenshot displays the ANSYS Electronics Desktop interface. The main workspace shows a 3D model of a radiated part, which is a rectangular board with a magenta-colored rectangle on its surface. A context menu is open over the magenta rectangle, listing various actions such as 'Expand All', 'Collapse All', 'Select', 'Edit', 'Group', 'Create 3D Component...', 'Assign Material...', 'View', 'Properties...', 'Create Array...', 'Create Open Region...', 'Update Open Region Padding...', 'Assign Boundary', 'Assign Excitation', 'Assign Hybrid', 'Assign Mesh Operation', 'Plot Fields', 'Plot Mesh...', and 'Plot VRT...'. The 'Properties...' option is highlighted.

The Properties panel on the left shows the following details for the selected 'Rectangle1':

Name	Value	Unit	Evaluated Value
Name	Rectangle1		
Orientation	Global		
Model	<input checked="" type="checkbox"/>		
Group	Model		
Display Wi...	<input type="checkbox"/>		
Material A...	<input type="checkbox"/>		
Color			
Transparent	0		

The Project Manager on the left shows the hierarchy of the model, including 'Solids', 'Sheets', and 'Unassigned' objects. The 'Rectangle1' object is highlighted in the 'Unassigned' folder.

The Message Manager at the bottom shows a warning message: 'Cannot create rectangle with zero length/width. (5:59:52 AM Apr 14, 2020)'. The status bar at the bottom indicates the current time is 6:03 AM on 4/14/2020.

Radiated Part – Assign Boundary- Perfect E

The screenshot displays the ANSYS Electronics Desktop interface. The main 3D view shows a pink rectangular region on a grey substrate, with a context menu open over it. The menu path is: Assign Boundary > Perfect E... The Properties panel on the left shows the selected object is 'Rectangle1' with a red color. The Project Manager on the left shows the hierarchy: Project1* > HFSSDesign2 (DrivenModal)* > Model > Perfect E > CreateRectangle. The Message Manager at the bottom shows error messages: 'Cannot create rectangle with zero length/width' and 'Invalid part name: Valid characters are letters, numbers, underscores.'

Project Manager

- Project1*
- HFSSDesign2 (DrivenModal)*
 - Definitions
 - Components
 - Symbols
 - Footprints
 - Padstacks
 - Models
 - Packages
 - Materials
 - Surface Materials
 - Scripts

Model

- Solids
 - Rogers RT/duroid 5870 (Material)
 - Box1
 - CreateBox
- Sheets
 - Perfect E
 - GND
 - CreateRectangle
 - CoverLines
 - Unassigned
 - Rectangle1
 - CreateRectangle
 - CoverLines
- Coordinate System
- Planes
- Lists

Properties

Name	Value	Unit	Evaluated Value
Name	Rectangle1		
Orientation	Global		
Model	<input checked="" type="checkbox"/>		
Group	Model		
Display Width	<input type="checkbox"/>		
Material Assign	<input type="checkbox"/>		
Color	 		
Transparent	0		

Message Manager

- Project1 (C:/Users/ckk/Documents/Ansoft/)
 - HFSSDesign2 (DrivenModal)
 - Cannot create rectangle with zero length/width. (5:59:52 AM Apr 14, 2020)
 - Invalid part name: Valid characters are letters, numbers, underscores. (6:00:00 AM Apr 14, 2020)

Assign Perfect E Boundary

- Hide 2 Messages
- Hide Progress

Feed Line

Project Manager

- 2020-Microstrip*
- HFSSDesign1 (DrivenModal)*
- Definitions

Model

- Solids
 - FR4_epoxy
 - Box1
 - CreateBox
 - vacuum
- Sheets
 - Perfect E
 - GND
 - RadPatch
 - Rectangle1
 - CreateRectangle
 - CoverLines

Properties: 2020-Microstrip - HFSSDesign1 - Modeler

Command

Name	Value	Unit	Evaluated Value	Description
Command	CreateRectangle			
Coordinate Sys...	Global			
Position	L/2, -wf/2, h		14.5mm, -0.5mm, 1.5mm	
Axis	Z			
XSize	Lamdag/4		15mm	
YSize	wf		1mm	

Show Hidden

OK Cancel Apply

0 35 70 (mm)

Progress

Feed Line– Assign Boundary- Perfect E

The screenshot displays the ANSYS Electronics Desktop interface. The main window shows a 3D model of a feed line structure on a grid. A context menu is open over the model, with the 'Assign Boundary' option selected. The 'Perfect E' option is highlighted within this menu. The Project Manager on the left shows the hierarchy: Project1* > HFSSDesign1 (DrivenModal)* > Model > Sheets > Perfect E. The Message Manager at the bottom shows simulation progress and warnings. The Windows taskbar at the very bottom shows the system clock as 3:19 PM on 4/16/2020.

ANSYS Electronics Desktop - Project1 - HFSSDesign1 - 3D Modeler - SOLVED - [Project1 - HFSSDesign1 - Modeler]

File Edit View Project Draw Modeler HFSS Tools Window Help

Save Cut Undo Select: Edge Select by Name Copy Redo Paste Delete Zoom Pan Rotate Orient Fit All Fit Selected Zoom Rotate Orient Mirror Move Rotate Subtract Imprint Intersect Unite Split Fillet Chamfer Measure Ruler Grid Model XY 3D vacuum Material

Desktop View Draw Model Simulation Results Automation

Project Manager

- Project1*
- HFSSDesign1 (DrivenModal)*
 - 3D Components
 - Model
 - Circuit Elements
 - Boundaries
 - Excitations
 - Hybrid Regions
 - Mesh Operations
 - Analysis
 - Optimetrics
 - Results
 - S Parameter Plot 1
 - Gain Plot 2
 - Gain Plot 3
 - Port Field Display
 - Field Overlays
 - Radiation
 - Definitions

Model

- Solids
 - FR4_epoxy
 - Box1
 - CreateBox
- vacuum
- Sheets
 - Perfect E
 - GND
 - CreateRectangle
 - CoverLines
 - RadPatch
 - REC
 - Lumped
 - Feed
- Coordinate System
- Planes
- Lists

Assign Boundary

- Expand All
- Collapse All
- Select
- Edit
- Group
- Create 3D Component...
- Assign Material...
- View
- Properties...
- Create Array ...
- Create Open Region ...
- Update Open Region Padding...
- Assign Boundary
- Assign Excitation
- Assign Hybrid
- Assign Mesh Operation
- Plot Fields
- Plot Mesh...
- Plot VRT...

Perfect E...

- Anisotropic Impedance...
- Aperture...
- Finite Conductivity...
- Half Space...
- Impedance...
- Layered Impedance...
- Linked Impedance...
- Lumped RLC...
- Master...
- Perfect E...
- Perfect H...
- Radiation...
- Slave...
- Symmetry...
- PML Setup Wizard...

Progress

Interpolating frequency sweep complete. Converged. (2:48:28 PM Apr 16 2020)

Normal completion of simulation on server: Local Machine. (2:48:28 PM Apr 16 2020)

HFSSDesign1: Solutions have been invalidated. Undo to recover. (3:09:08 PM Apr 16 2020)

Adaptive Passes did not converge based on specified criteria. (3:09:08 PM Apr 16 2020)

Hide 10 Messages Hide Progress

3:19 PM 4/16/2020

Feed – Lumped Port

The image displays a 3D modeling software interface for a microstrip design. The Project Manager on the left shows the hierarchy: 2020-Microstrip* > HFSSDesign1 (DrivenModal)* > Definitions. The Model tree on the right lists the components: Solids (FR4_epoxy, Box1, CreateBox), vacuum, Sheets (Perfect E, GND, RadPatch, Rectangle1, Lumped Port, Feed), CreateRectangle, and CoverLines.

The Properties dialog box for the selected 'Feed' object is open, showing the following details:

Name	Value	Unit	Evaluated Value	Description
Command	CreateRectangle			
Coordinate Sys...	Global			
Position	Ls/2, -0.5mm, 0mm		29.5mm, -0.5mm, 0mm	
Axis	X			
YSize	1	mm	1mm	
ZSize	h		1.5mm	

The 3D view shows a dark red rectangular substrate with a green microstrip layer. A red square represents the lumped port feed, centered on the green layer. A coordinate system with X, Y, and Z axes is visible. A scale bar at the bottom indicates dimensions from 0 to 70 mm, with a midpoint at 35 mm. The progress bar at the very bottom shows the current status of the simulation or rendering process.

Feed – Lumped Port

ANSYS Electronics Desktop - Project1 - HFSSDesign2 - 3D Modeler - [Project1 - HFSSDesign2 - Modeler]

File Edit View Project Draw Modeler HFSS Tools Window Help

Save Cut Undo Select: Edge Select by Name Copy Redo Paste Delete Zoom Pan Rotate Orient Fit All Fit Selected Move Rotate Mirror Unite Subtract Imprint Intersect Split Fillet Chamfer Measure Ruler Units Grid XY 3D Model vacuum Material

Desktop View Draw Model Simulation Results Automation

Project Manager

- Project1*
 - HFSSDesign2 (DrivenModal)*
 - Definitions
 - Components
 - Symbols
 - Footprints
 - Padstacks
 - Models
 - Packages
 - Materials
 - Surface Materials
 - Scripts

Model

- Solids
 - Rogers RT/duroid 5870 (Box1
 - CreateBox
- Sheets
 - Perfect E
 - feed
 - CreateRectangle
 - CoverLines
 - GND
 - CreateRectangle
 - radp
 - Unassign
 - Rect
- Coordinate System
- Planes
- Lists

Assign Material... View Properties... Create Array ... Create Open Region ... Update Open Region Padding... Assign Boundary Assign Excitation Assign Hybrid Assign Mesh Operation Plot Fields Plot Mesh... Plot VRT... Wave Port... Lumped Port... Floquet Port... Terminal... Incident Wave Linked Field Voltage... Current... Magnetic Bias...

Message Manager

- Cannot create rectangle with zero length/width. (5:59:52 AM Apr 14, 2020)
- Invalid part name: Valid characters are letters, numbers, underscores. (6:11:18 AM Apr 14, 2020)
- Boundary 'PerfE2': Boundary lost its assignment due to geometry modification. (6:11:18 AM Apr 14, 2020)
- Warning - Boundary 'PerfE1' and Boundary 'PerfE2' overlap. (6:11:18 AM Apr 14, 2020)

Assign a Lumped Port Excitation

Progress

Hide 4 Messages Hide Progress

6:23 AM 4/14/2020

Feed – Lumped Port

The screenshot displays the ANSYS Electronics Desktop 3D Modeler interface. The main workspace shows a 3D model of a feed structure on a grid. A red line represents the feed, and a green line represents the lumped port. The coordinate system is Global, with the Z-axis pointing upwards. The tree view on the left shows the model hierarchy, including Solids, Sheets, and Unassigned. The Message Manager at the bottom displays several error messages:

- Cannot create rectangle with zero length/width. (5:59:52 AM Apr 14, 2020)
- Invalid part name: Valid characters are letters, numbers, underscores. (6:04:43 AM Apr 14, 2020)
- Boundary 'PerfE2': Boundary lost its assignment due to geometry modifications and has been deleted. (6:10:44 AM Apr 14, 2020)
- Warning - Boundary 'PerfE1' and Boundary 'PerfE2' overlap. (6:11:18 AM Apr 14, 2020)

The status bar at the bottom shows the current position (dX: 0, dY: 0, dZ: 0.5) and units (mm).

50ohm- NewLine

Radiation

ANSYS Electronics Desktop - Project1 - HFSSDesign1 - 3D Modeler - SOLVED - [Project1 - HFSSDesign1 - Modeler]

File Edit View Project Draw Modeler HFSS Tools Window Help

Save Cut Copy Paste Undo Redo Delete Select: Edge Select by Name Zoom Pan Rotate Orient Fit All Fit Selected Move Rotate Mirror Unite Subtract Imprint Intersect Fillet Chamfer Measure Ruler Units Grid XY 3D Model vacuum Material

Desktop View Draw Model Simulation Results Automation

Project Manager

- Project1*
- HFSSDesign1 (DrivenModal)*
 - 3D Components
 - Model
 - FR4_epoxy
 - Box1
 - CreateBox
 - vacuum
 - Sphere1
 - CreateSphere
 - Circuit Elements
 - Boundaries
 - Excitations
 - Hybrid Regions
 - Mesh Operations
 - Analysis
 - Optimetrics
 - Results
 - S Parameter Plot 1
 - Gain Plot 1
 - Gain Plot 2
 - Gain Plot 3
 - Port Field Display
 - Field Overlays
 - Radiation
 - Definitions

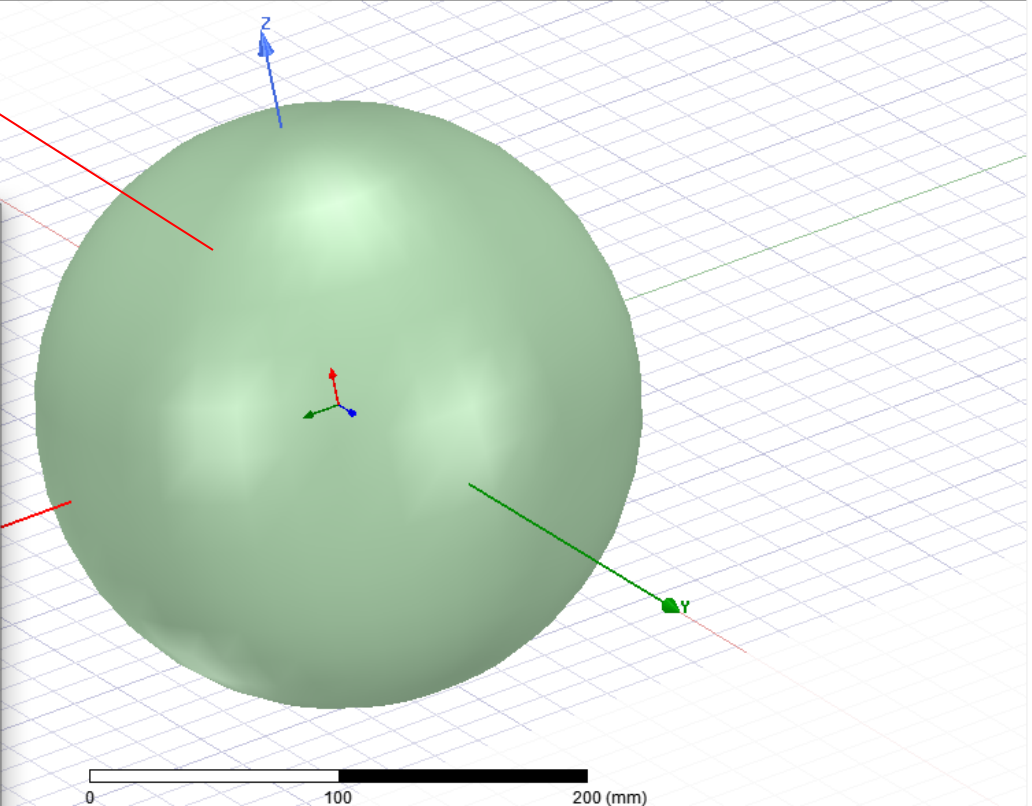
Properties: Project1 - HFSSDesign1 - Modeler

Command

Name	Value	Unit	Evaluated Value
Command	CreateSphere		
Coordinate Sys...	Global		
Center Position	0,0,0	mm	0mm, 0mm, 0mm
Radius	Lambda		125mm

Show Hidden

OK Cancel Apply



0 100 200 (mm)

Message Manager

- Interpolating frequency sweep complete. Converged. (3:09:08 PM Apr 16, 2020)
- Normal completion of simulation on server: Local Machine. (3:09:08 PM Apr 16, 2020)
- HFSSDesign1: Solutions have been invalidated. Undo to recover. (3:22:37 PM Apr 16, 2020)

Project1 - HFSSDesign1 - Setup1: Adaptive Pass #3 - Solving single frequency for adaptive meshing ... on Local Machine - RUNNING

Hide 11 Messages Hide Progress

Windows Taskbar: 3:22 PM 4/16/2020

Assign Boundary - Radiation

The screenshot displays the ANSYS Electronics Desktop interface. The main window shows a 3D model of a spherical object with a coordinate system (X, Y, Z) and a scale bar (0 to 200 mm). A context menu is open over the sphere, with the 'Assign Boundary' option selected. The 'Assign Boundary' submenu is visible, showing 'Radiation...' as the chosen option. The Project Manager on the left shows the hierarchy: Project1* > HFSSDesign2 (DrivenModal)* > Definitions > Models > Spheres > Sphere1. The Message Manager at the bottom shows several error and warning messages related to boundary assignments.

ANSYS Electronics Desktop - Project1 - HFSSDesign2 - 3D Modeler - [Project1 - HFSSDesign2 - Modeler]

File Edit View Project Draw Modeler HFSS Tools Window Help

Save Cut Undo Select: Edge Copy Redo Select by Name Paste Delete Zoom Pan Fit All Fit Selected Rotate Orient

Move Rotate Mirror Unite Subtract Intersect Split Imprint Chamfer Measure Ruler Grid XY 3D Model vacuum Material

Desktop View Draw Model Simulation Results Automation

Project Manager

- Project1*
- HFSSDesign2 (DrivenModal)*
 - Definitions
 - Components
 - Symbols
 - Footprints
 - Padstacks
 - Models
 - Packages
 - Materials
 - Surface Materials
 - Scripts

Model

- Solids
 - Rogers RT/duroid 5870 (
 - Box1
 - CreateBox
 - vacuum
 - Sphere1
- Sheets
- Lumped
- Perfect
- feec
- GNL
- radi
- Coordinate Sys
- Planes
- Lists

Assign Boundary

- Expand All
- Collapse All
- Select >
- Edit >
- Group >
- Create 3D Component...
- Assign Material...
- View >
- Properties...
- Create Array ...
- Create Open Region ...
- Update Open Region Padding...
- Assign Boundary >
- Assign Excitation >
- Assign Hybrid >
- Assign Mesh Operation >
- Plot Fields >
- Plot Mesh...
- Plot VRT...
- Anisotropic Impedance...
- Aperture...
- Finite Conductivity...
- Half Space...
- Impedance...
- Layered Impedance...
- Linked Impedance...
- Lumped RLC...
- Master...
- Perfect E...
- Perfect H...
- Radiation...
- Slave...
- Symmetry...
- PML Setup Wizard...

Message Manager

- Cannot create rectangle with zero length/width. (5:59:52 AM Apr 14, 2020)
- Invalid part name: Valid characters are letters, numbers, underscores. (6:04:43 AM Apr 14, 2020)
- Boundary 'PerfE2': Boundary lost its assignment due to geometry modifications and has been deleted. (6:10:44 AM Apr 14, 2020)
- Warning - Boundary 'PerfE1' and Boundary 'PerfE2' overlap. (6:11:18 AM Apr 14, 2020)

Progress

Hide 4 Messages Hide Progress

6:28 AM 4/14/2020

HFSS-Radiation-Insert Far Field Setup – Infinite Sphere

The screenshot displays the ANSYS Electronics Desktop interface. The main window shows a 3D model of a sphere on a grid. The 'HFSS' menu is open, and the path 'Radiation > Insert Far Field Setup > Infinite Sphere...' is highlighted. A blue arrow points to the 'Radiation' menu item. The 'Project Manager' on the left shows the project structure. The 'Message Manager' at the bottom displays several error and warning messages. The Windows taskbar at the bottom shows the system tray with the date and time as 6:30 AM on 4/14/2020.

ANSYS Electronics Desktop - Project1 - HFSSDesign2 - 3D Modeler - [Project1 - HFSSDesign2 - Modeler]

File Edit View Project Draw Modeler HFSS Tools Window Help

Save Cut Undo Select: Edge Copy Redo Select by Name Paste Delete

Desktop View Draw Model Sim

Project Manager

- Project1*
- HFSSDesign2 (DrivenModal)*
 - Definitions
 - Components
 - Symbols
 - Footprints
 - Padstacks
 - Models
 - Packages
 - Materials
 - Surface Materials
 - Scripts

Solution Type...
List...
Validation Check...
Analyze All
Submit Job...
Edit Notes...
Toolkit
3D Model Editor
Set Object Temperature...
Design Settings...
Model
Boundaries
Excitations
Hybrid
Mesh Operations
Analysis Setup
Optimetrics Analysis
Fields
Radiation > Insert Far Field Setup > Infinite Sphere...
Results > Insert Near Field Setup > Antenna Parameter Overlay...
Boundary Display (Solver View)
Design Properties...
Design Datasets...

Move Rotate Mirror
Unite Subtract Imprint
Fillet Chamfer
Measure Ruler
Grid
Model vacuum
Material

0 100 200 (mm)

Message Manager

- Cannot create rectangle with zero length/width. (5:59:52 AM Apr 14, 2020)
- Invalid part name: Valid characters are letters, numbers, underscores. (6:04:43 AM Apr 14, 2020)
- Boundary 'PerE2': Boundary lost its assignment due to geometry modifications and has been deleted. (6:10:44 AM Apr 14, 2020)
- Warning - Boundary 'PerE1' and Boundary 'PerE2' overlap. (6:11:18 AM Apr 14, 2020)

Progress

Not enough memory reserve!

Hide 4 Messages Hide Progress

6:30 AM
4/14/2020

HFSS-Radiation-Insert Far Field Setup – Infinite Sphere

The screenshot displays the ANSYS Electronics Desktop interface for a 3D modeler. The main window shows a 3D view of a sphere with a coordinate system (X, Y, Z) and a grid. A dialog box titled "Far Field Radiation Sphere Setup" is open, showing the "Infinite Sphere" tab. The dialog box contains the following settings:

- Name: Infinite Sphere1
- Phi: Start 0 deg, Stop 360 deg, Step Size 5 deg
- Theta: Start 0 deg, Stop 360 deg, Step Size 5 deg

The dialog box also has buttons for "Save As Defaults", "View Sweep Points...", "OK", "Cancel", and "Help".

The Project Manager on the left shows the following structure:

- Project1*
- HFSSDesign2 (DrivenModal)*
- Definitions
- Components
- Symbols
- Footprints
- Padstacks
- Models
- Packages
- Materials
- Surface Materials
- Scripts

The Model tree on the right shows the following structure:

- Model
- Solids
- Rogers RT/duroid 5870 (
- Box1
- CreateBox
- vacuum
- Sphere1
- CreateSphere
- Sheets
- Lumped Port
- Perfect E
- feed
- CreateRectangle
- CoverLines
- GND
- CreateRectangle
- CoverLines
- radpart
- CreateRectangle
- CoverLines
- Coordinate Systems
- Planes
- Lists

The Message Manager at the bottom shows the following messages:

- Cannot create rectangle with zero length/width. (5:59:52 AM Apr 14, 2020)
- Invalid part name: Valid characters are letters, numbers, underscores. (6:04:43 AM Apr 14, 2020)
- Boundary 'PerfE2': Boundary lost its assignment due to geometry modifications and has been deleted. (6:10:44 AM Apr 14, 2020)
- Warning - Boundary 'PerfE1' and Boundary 'PerfE2' overlap. (6:11:18 AM Apr 14, 2020)

The Windows taskbar at the bottom shows the system tray with the date and time: 6:32 AM 4/14/2020.

Radiation- No view

ANSYS Electronics Desktop - Project1 - HFSSDesign2 - 3D Modeler - [Project1 - HFSSDesign2 - Modeler]

File Edit View Project Draw Modeler HFSS Tools Window Help

Save Cut Undo Select: Edge Select by Name Paste Delete Zoom Pan Rotate Orient Fit All Fit Selected Zoom Rotate Orient Move Rotate Mirror Intersect Unite Subtract Imprint Fillet Chamfer Measure Ruler Grid XY 3D Model vacuum Material

Desktop View Draw Model Simulation Results Automation

Project Manager

- Project1*
- HFSSDesign2 (DrivenModal)*
 - 3D Components
 - Model
 - Circuit Elements
 - Boundaries
 - Excitations
 - Hybrid Regions
 - Mesh Operations
 - Analysis
 - Optimetrics
 - Results
 - Port Field Display
 - Field Overlays
 - Radiation
 - Definitions
 - Components
 - Symbols
 - Footprints
 - Padstacks
 - Models
 - Packages
 - Materials
 - Surface Materials
 - Scripts

Active View Visibility: Project1 - HFSSDesign2 - Modeler

3D Modeler | Color Keys | Array Setup | Boundaries | Excitations | FieldsReporter

	Name	Visibility
1	Box1	<input checked="" type="checkbox"/>
2	feed	<input checked="" type="checkbox"/>
3	GND	<input checked="" type="checkbox"/>
4	radpart	<input checked="" type="checkbox"/>
5	Rectangle1	<input checked="" type="checkbox"/>
6	Sphere1	<input type="checkbox"/>

Name Show Hide Done

Coordinate Systems Planes Lists

0 100 200 (mm)

Message Manager

- Cannot create rectangle with zero length/width. (5:59:52 AM Apr 14, 2020)
- Invalid part name: Valid characters are letters, numbers, underscores. (6:04:43 AM Apr 14, 2020)
- Boundary 'PerfE2': Boundary lost its assignment due to geometry modifications and has been deleted. (6:10:44 AM Apr 14, 2020)
- Warning - Boundary 'PerfE1' and Boundary 'PerfE2' overlap. (6:11:18 AM Apr 14, 2020)

Nothing is selected

Hide 4 Messages Hide Progress

6:34 AM 4/14/2020

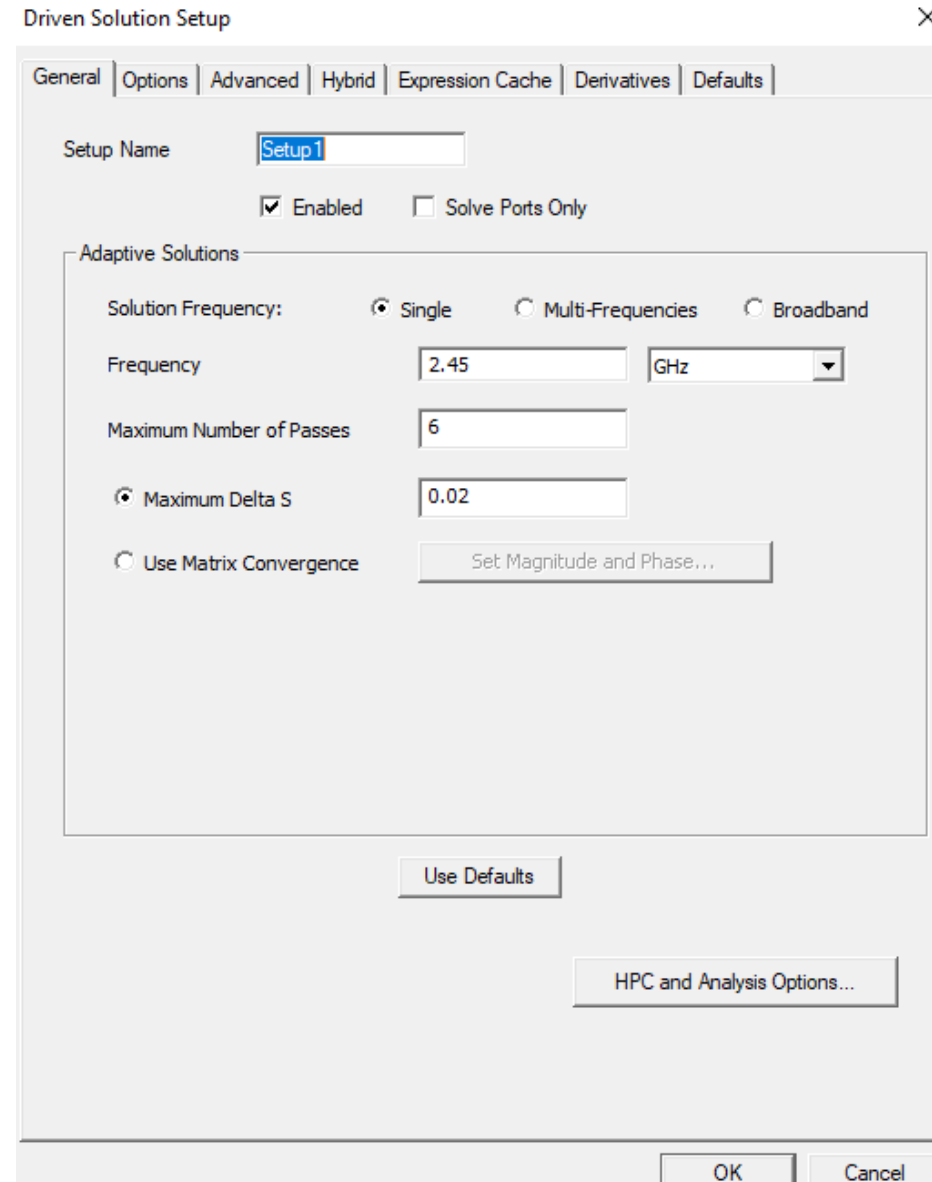
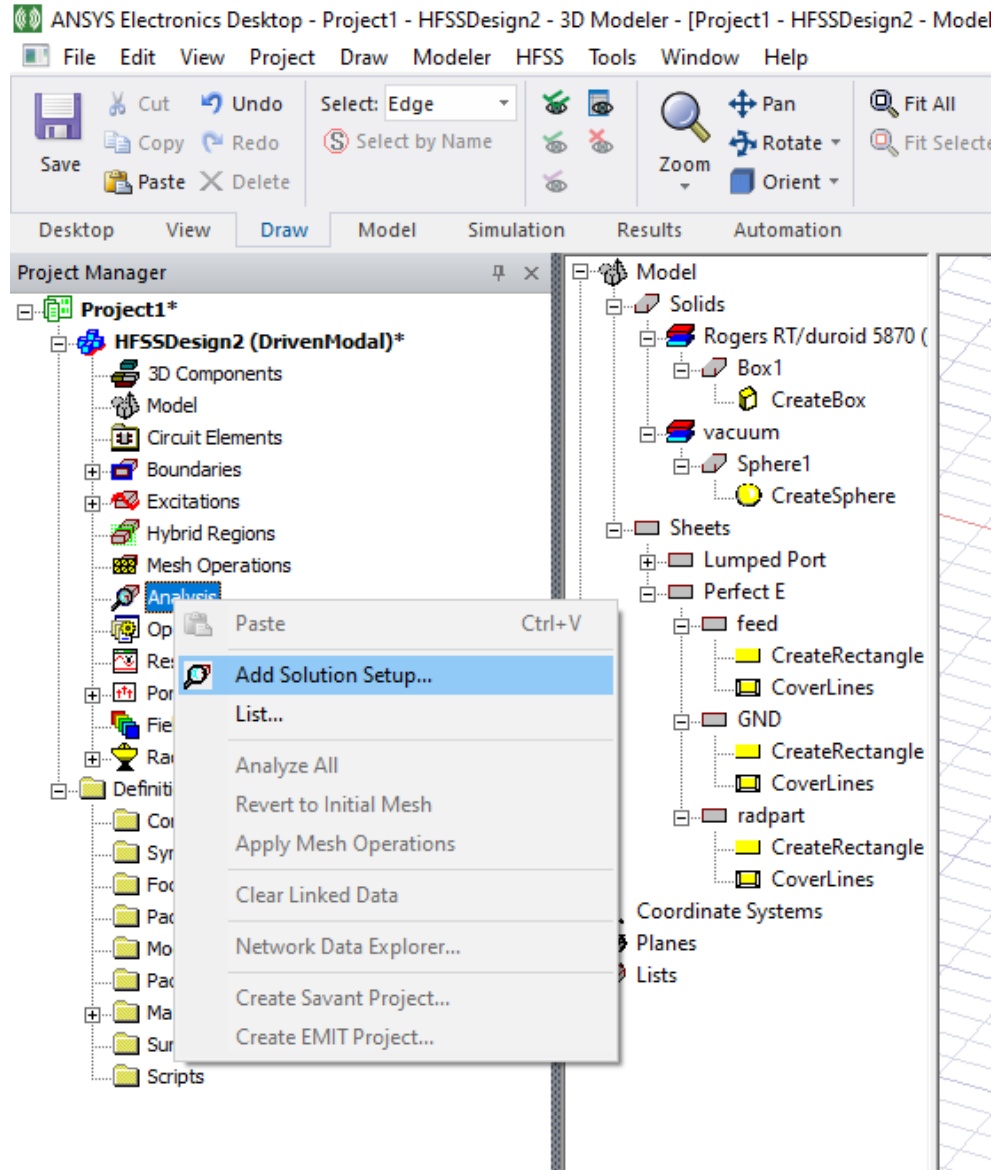
Parametrik değerlerin değiştirilmesi

The image shows a CAD software interface with a 3D model of a microstrip antenna. The model consists of a red square patch on a green rectangular substrate, which is placed on a brown base. A coordinate system with X, Y, and Z axes is visible. A scale bar at the bottom indicates 0, 35, and 70 mm.

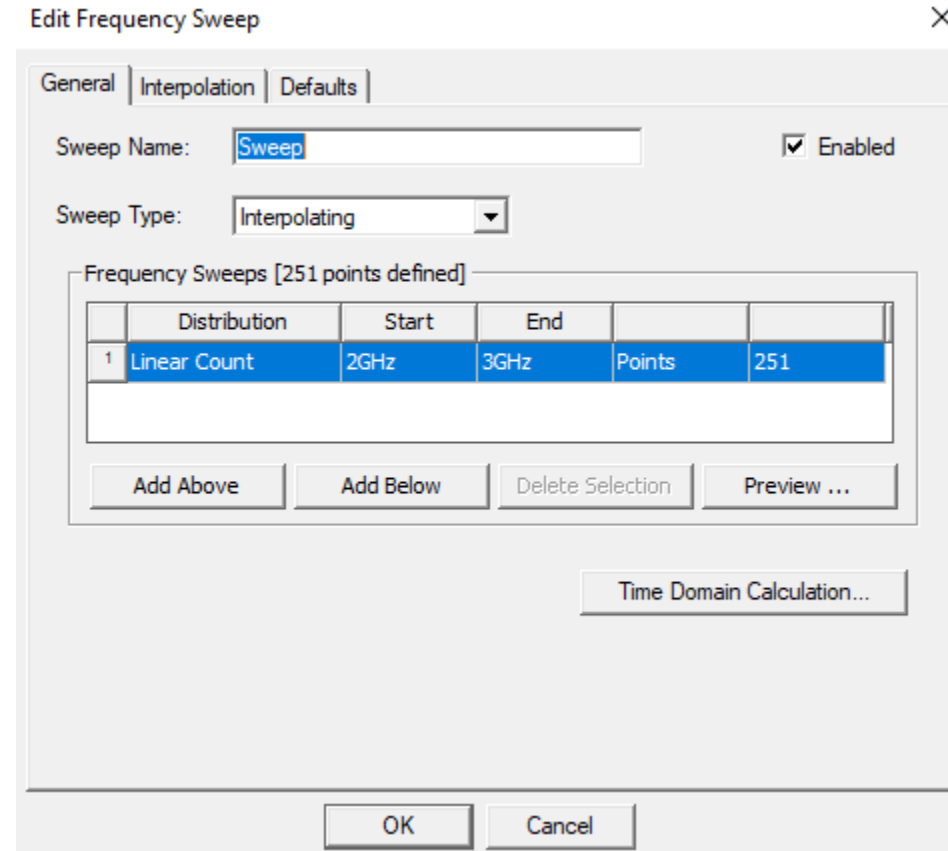
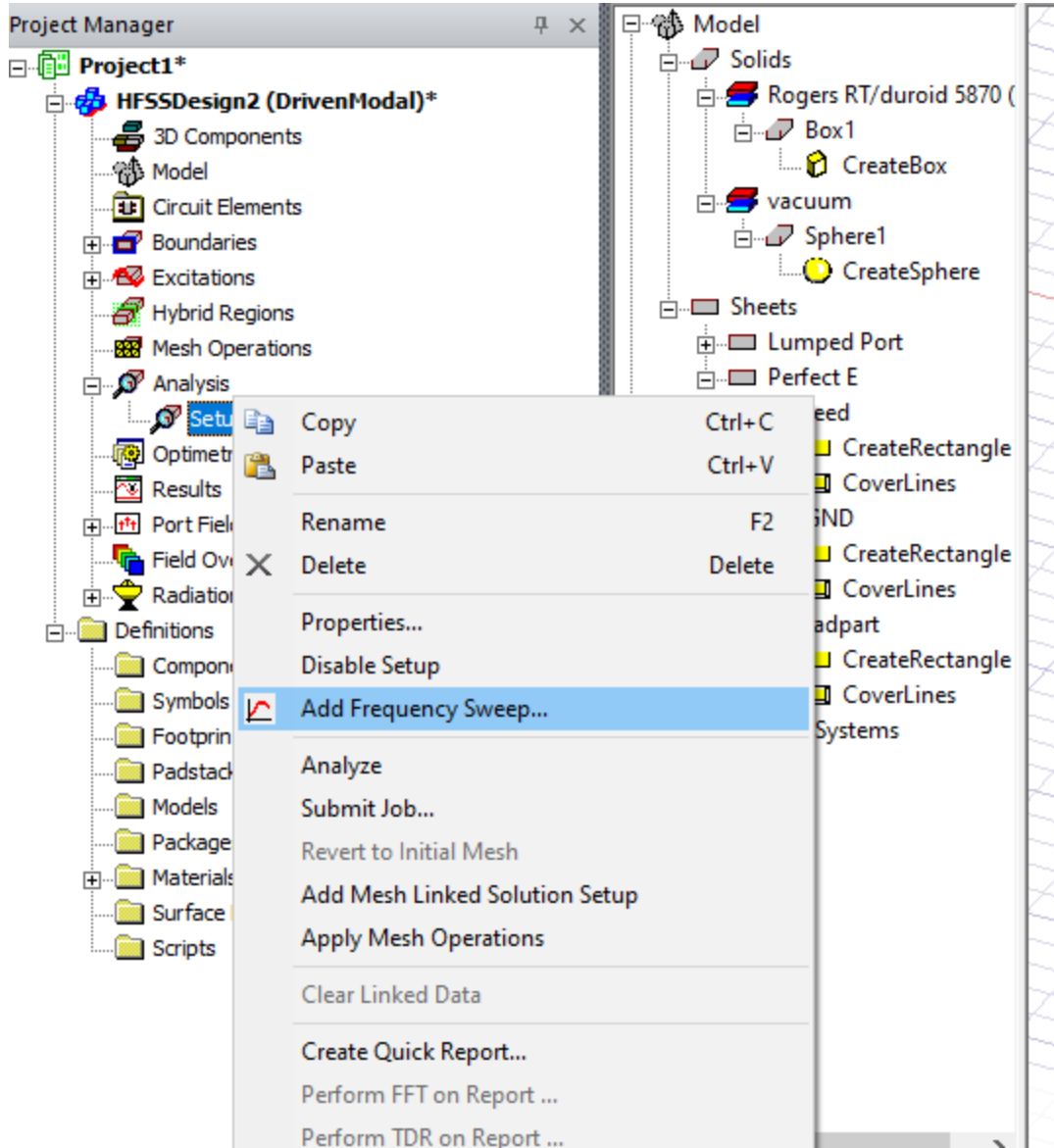
The 'Properties: 2020-Microstrip - HFSS Design1' dialog box is open, showing a table of local variables. A black arrow points from the 'wf' parameter in the table to the red patch in the 3D model.

Name	Value	Unit	Evaluated Value	Type	Description	Read-only	Hidden
wf	1	mm	1mm	Design		<input type="checkbox"/>	<input type="checkbox"/>
Lamda	125	mm	125mm	Design		<input type="checkbox"/>	<input type="checkbox"/>
L	29	mm	29mm	Design		<input type="checkbox"/>	<input type="checkbox"/>
Lamdag	60	mm	60mm	Design		<input type="checkbox"/>	<input type="checkbox"/>
Lg	Lamda		125mm	Design		<input type="checkbox"/>	<input type="checkbox"/>
W	38	mm	38mm	Design		<input type="checkbox"/>	<input type="checkbox"/>
Wg	Lamda		125mm	Design		<input type="checkbox"/>	<input type="checkbox"/>
h	1.5	mm	1.5mm	Design		<input type="checkbox"/>	<input type="checkbox"/>
LS	59	mm	59mm	Design		<input type="checkbox"/>	<input type="checkbox"/>
Ws	68	mm	68mm	Design		<input type="checkbox"/>	<input type="checkbox"/>

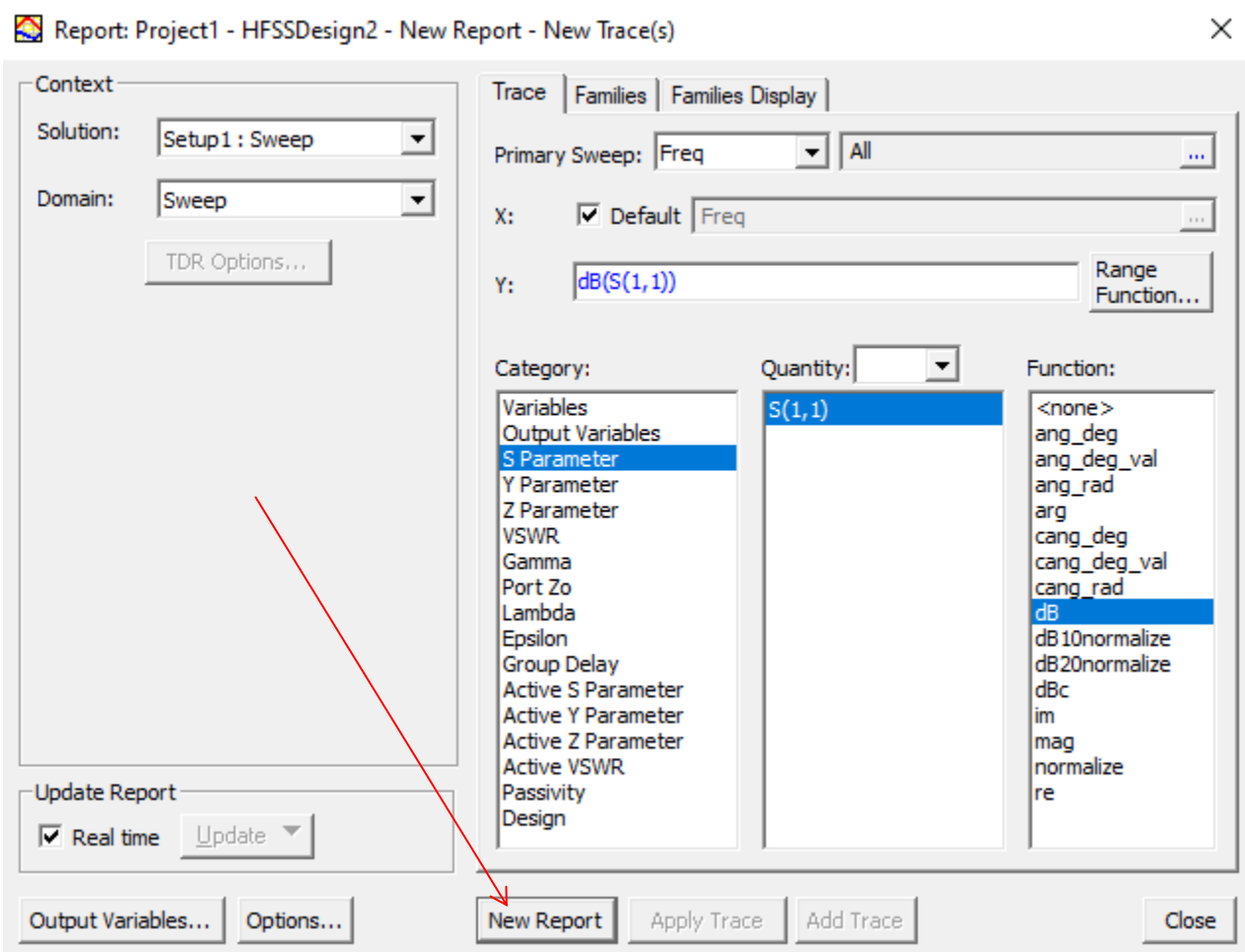
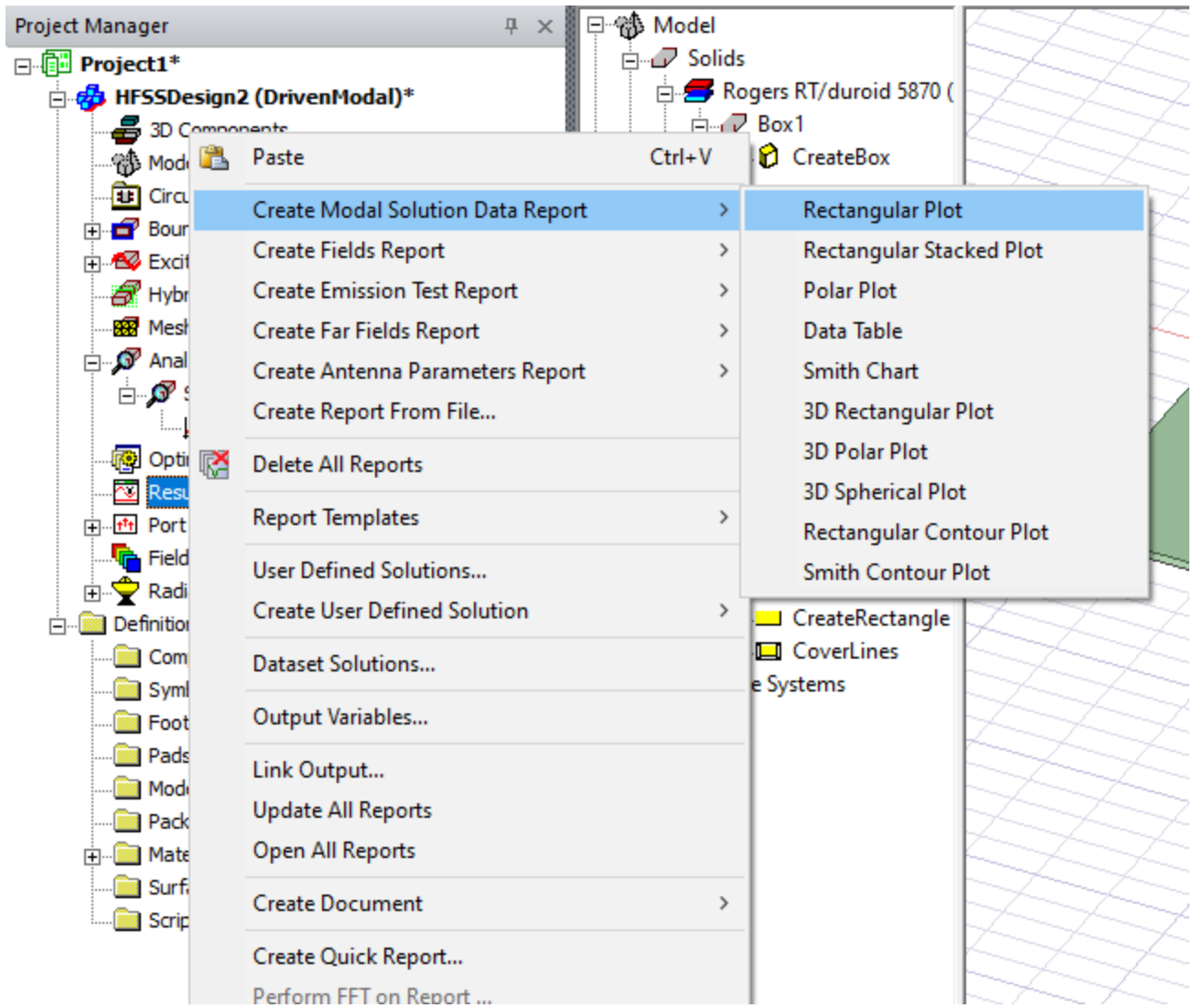
Analysis



Analysis



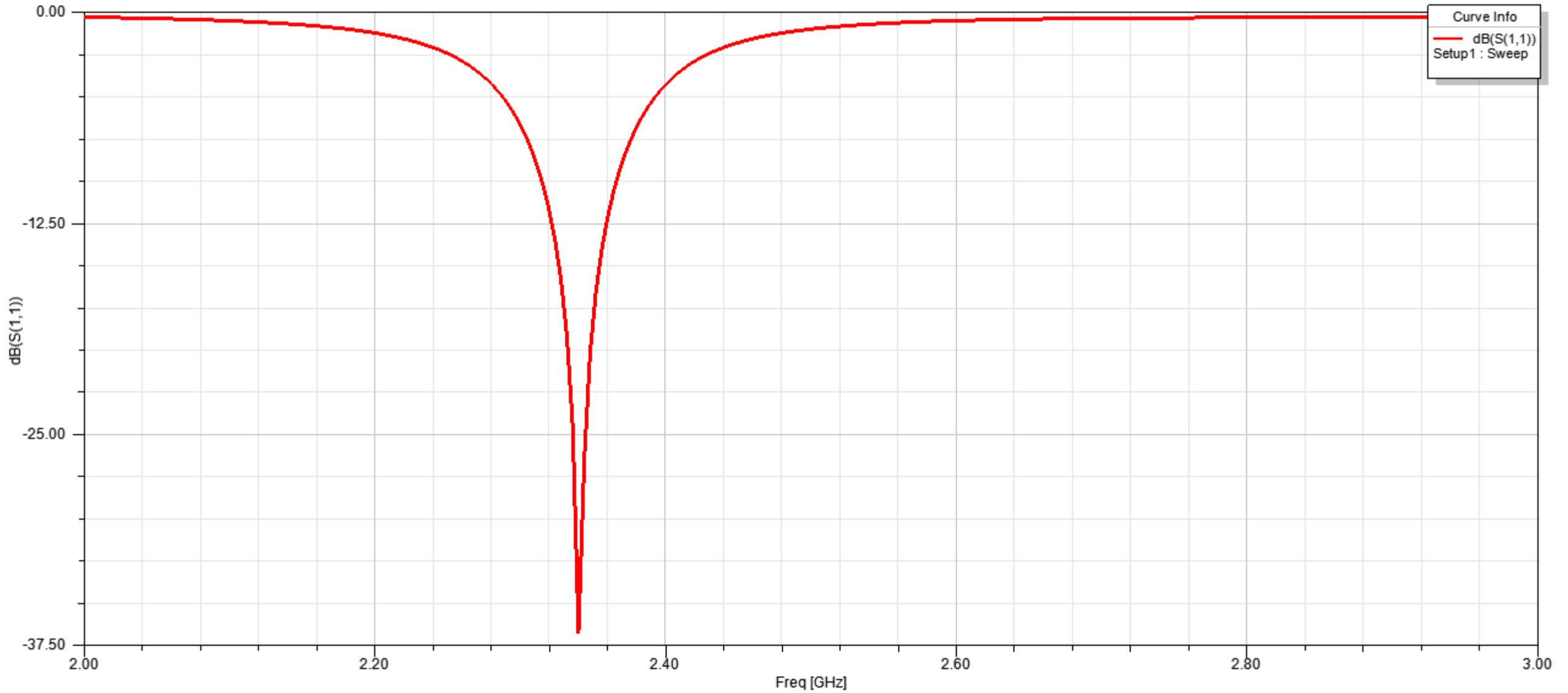
Test: Return Loss, S11



Test S11

S Parameter Plot 1

HFSSDesign1 



Test – Pattern

This screenshot shows a plot of radiation pattern in HFSS. The plot displays a red curve on a grid. The x-axis has labels at 2.25 and 2.5. A context menu is open over the plot, listing various report options. The 'Create Far Fields Report' option is selected, and its sub-menu is also open, showing options like 'Rectangular Plot', 'Rectangular Stacked Plot', 'Radiation Pattern', 'Data Table', '3D Rectangular Plot', '3D Polar Plot', and 'Rectangular Contour Plot'. The '3D Polar Plot' option is highlighted in blue.

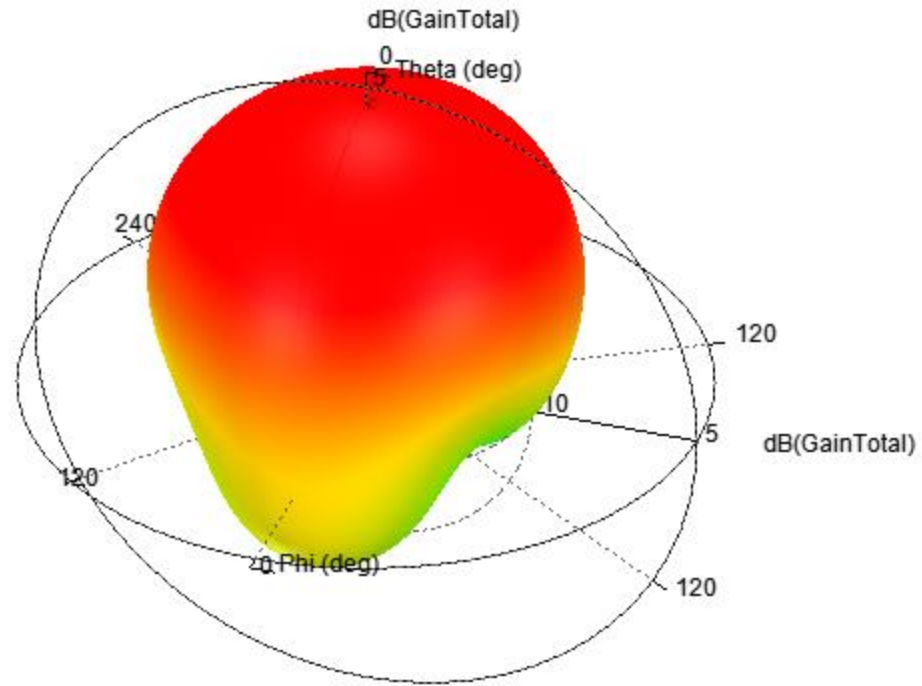
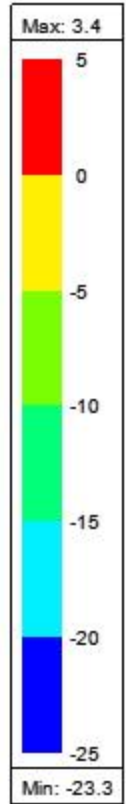
- Paste (Ctrl+V)
- Create Modal Solution Data Report >
- Create Fields Report >
- Create Emission Test Report >
- Create Far Fields Report >**
 - Rectangular Plot
 - Rectangular Stacked Plot
 - Radiation Pattern
 - Data Table
 - 3D Rectangular Plot
 - 3D Polar Plot**
 - 3D Spherical Plot
 - Rectangular Contour Plot
- Create Antenna Parameters Report >
- Create Report From File...
- Delete All Reports
- Report Templates >
- User Defined Solutions...
- Create User Defined Solution >
- Dataset Solutions...
- Output Variables...
- Link Output...
- Update All Reports
- Open All Reports
- Create Document >
- Create Quick Report...
- Perform FFT on Report ...
- Perform TDR on Report ...
- Solution Data...
- Tune Reports ...
- Browse Solutions...
- Clean Up Solutions...
- Import Solutions...
- Apply Solved Variation...

This screenshot shows the same plot of radiation pattern in HFSS. The plot displays a red curve on a grid. The x-axis has labels at 2.25 and 2.5. A context menu is open over the plot, listing various report options. The 'Create Far Fields Report' option is selected, and its sub-menu is also open, showing options like 'Rectangular Plot', 'Rectangular Stacked Plot', 'Radiation Pattern', 'Data Table', '3D Rectangular Plot', '3D Polar Plot', and 'Rectangular Contour Plot'. The 'Radiation Pattern' option is highlighted in blue.

- Paste (Ctrl+V)
- Create Modal Solution Data Report >
- Create Fields Report >
- Create Emission Test Report >
- Create Far Fields Report >**
 - Rectangular Plot
 - Rectangular Stacked Plot
 - Radiation Pattern**
 - Data Table
 - 3D Rectangular Plot
 - 3D Polar Plot
 - 3D Spherical Plot
 - Rectangular Contour Plot
- Create Antenna Parameters Report >
- Create Report From File...
- Delete All Reports
- Report Templates >
- User Defined Solutions...
- Create User Defined Solution >
- Dataset Solutions...
- Output Variables...
- Link Output...
- Update All Reports
- Open All Reports
- Create Document >
- Create Quick Report...
- Perform FFT on Report ...
- Perform TDR on Report ...
- Solution Data...
- Tune Reports ...
- Browse Solutions...

Test – Pattern

Gain Plot 1



Test: E-Pattern

ANSYS Electronics Desktop - Project1 - HFSSDesign2 - Gain Plot 2 - SOLVED - [Project1 - HFSSDesign2 - Gain Plot 2]

File Edit View Project Report2D HFSS Tools Window Help

Save Cut Copy Paste Undo Redo Delete Docking Windows Layouts Zoom Zoom In Zoom Out Pan Fit All Fit Selected

Desktop View Simulation Results Automation

Project Manager

- Project1*
 - HFSSDesign2 (DrivenModal)*
 - 3D Components
 - Model
 - Circuit Elements
 - Boundaries
 - Excitations
 - Hybrid Regions
 - Mesh Operations
 - Analysis
 - Setup1
 - Sweep
 - Optimetrics
 - Results
 - S Parameter Plot 1
 - dB(S(1,1))
 - Gain Plot 1
 - dB(GainTotal)
 - Gain Plot 2**
 - dB(GainTotal)
 - Port Field Display
 - Field Overlays
 - Radiation
 - Definitions
 - Components
 - Symbols
 - Footprints
 - Padstacks
 - Models
 - Packages
 - Materials
 - Surface Materials

Gain Plot 2

Report: Project1 - HFSSDesign2 - Gain Plot 2 - dB(GainTotal)

Context: Solution: Setup1: LastAdaptive Geometry: Infinite Sphere1

Trace Families Families Display

Families: 1 available

Sweeps Available variations

Variable	Value	Edit
Phi	0deg	...
Freq	3GHz	...

Update Report: Real time Update

Output Variables... Options... New Report Apply Trace Add Trace Close

HFSSDesign2

Curve Info

- dB(GainTotal) Setup1: LastAdaptive Freq=3GHz' Phi=0deg'
- dB(GainTotal) Setup1: LastAdaptive Freq=3GHz' Phi=5deg'
- dB(GainTotal) Setup1: LastAdaptive Freq=3GHz' Phi=10deg'
- dB(GainTotal) Setup1: LastAdaptive Freq=3GHz' Phi=15deg'
- dB(GainTotal) Setup1: LastAdaptive Freq=3GHz' Phi=20deg'
- dB(GainTotal) Setup1: LastAdaptive Freq=3GHz' Phi=25deg'
- dB(GainTotal) Setup1: LastAdaptive Freq=3GHz' Phi=30deg'
- dB(GainTotal) Setup1: LastAdaptive Freq=3GHz' Phi=35deg'
- dB(GainTotal) Setup1: LastAdaptive Freq=3GHz' Phi=40deg'
- dB(GainTotal) Setup1: LastAdaptive Freq=3GHz' Phi=45deg'

Use all values Select values Specify range

0deg 5deg 10deg 15deg 20deg 25deg 30deg 35deg 40deg 45deg

Select All Clear All

Sweep: Default Edited

Message Manager

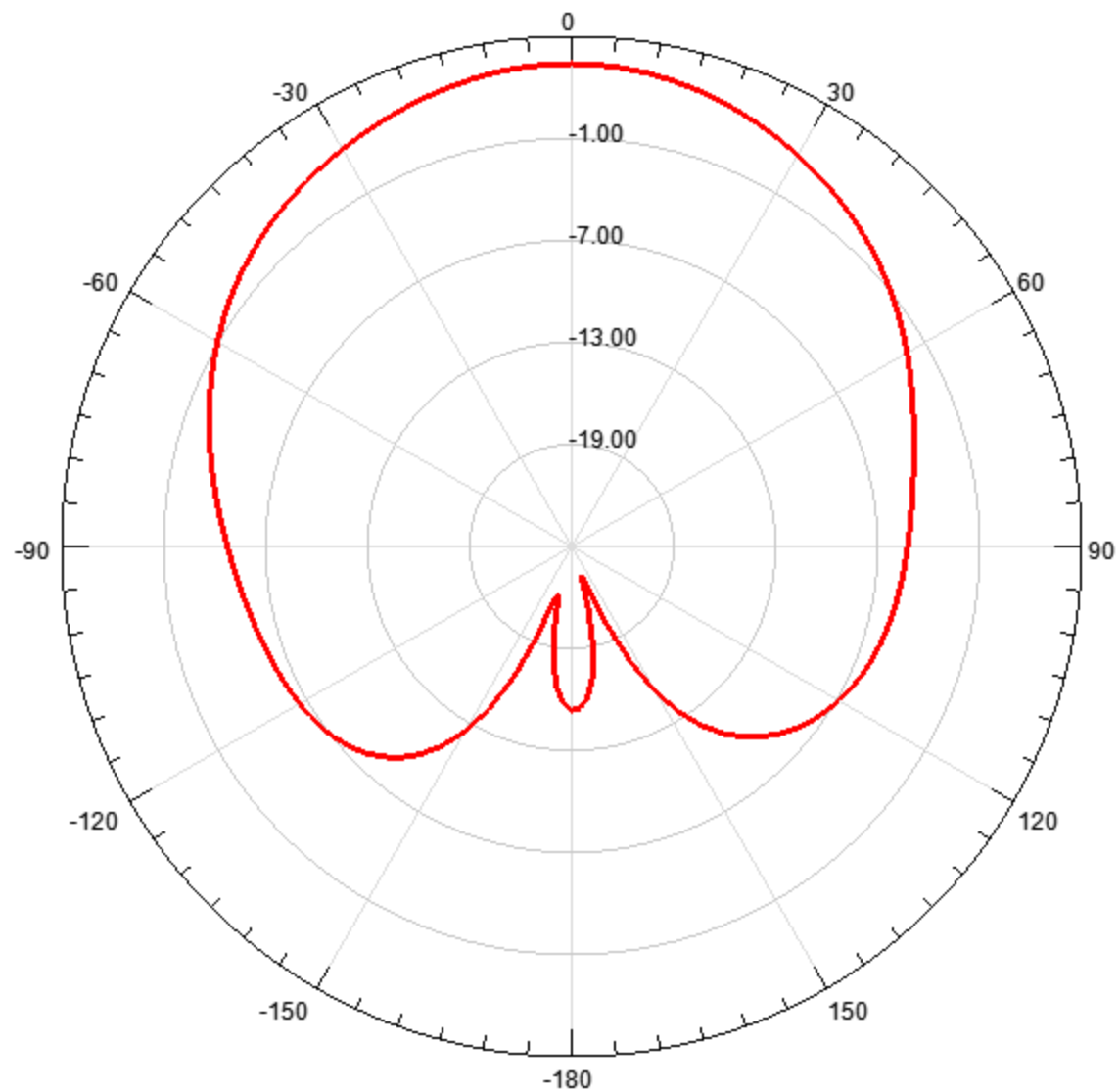
- Boundary 'PerE2': Boundary lost its assignment due to geometry modifications and has been deleted. (6:10:44 AM Apr 14, 2020)
- Warning - Boundary 'PerE1' and Boundary 'PerE2' overlap. (6:11:18 AM Apr 14, 2020)
- Simulation was aborted by user on server: Local Machine. (6:41:53 AM Apr 14, 2020)
- An interpolating frequency sweep with 451 points has been started using HFSS - Solving Distributed. (6:45:50 AM Apr 14, 2020)

Ready Hide 8 Messages Hide Progress Ang 120.6051 Mag 40.0684

6:51 AM 4/14/2020

Test: E-Pattern

Gain Plot 2



HFSSDesign1

Curve Info

— dB(GainTotal)
Setup1 : LastAdaptive
Freq=2.45GHz' Phi=0deg'

Test: H-Pattern

ANSYS Electronics Desktop - Project1 - HFSSDesign1 - Gain Plot 3 - SOLVED - [Project1 - HFSSDesign1 - Gain Plot 3]

File Edit View Project Report2D HFSS Tools Window Help

Save Cut Undo Copy Paste Delete Docking Windows Layouts Zoom Zoom In Zoom Out Pan Fit All Fit Selected

Desktop View Simulation Results Automation

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 - Mesh Operations
 - Analysis
 - Setup1
 - Sweep
 - Optimetrics
 - Results
 - S Parameter Plot 1
 - Gain Plot 1
 - Gain Plot 2
 - Gain Plot 3**
 - dB(GainTotal)
 - Port Field Display
 - Field Overlays
 - Radiation
 - Definitions

Gain Plot 3

Curve Info
— dB(GainTotal)
Setup1 : LastAdaptive
Freq=2.45GHz; Phi=90deg

Report: Project1 - HFSSDesign1 - Gain Plot 3 - dB(GainTotal)

Context
Solution: Setup1 : LastAdaptive
Geometry: Infinite Sphere1

Trace Families Families Display

Families : 1 available
 Sweeps Available variations

Variable	Value	Edit
Phi	90deg	...
Freq	2.45GHz	...

Use all values Select values Specify range

- 72deg
- 75deg
- 78deg
- 81deg
- 84deg
- 87deg
- 90deg**
- 93deg
- 96deg
- 99deg

Select All Clear All

Sweep: Default Edited

Nominals: L, Lamda, Lamdag, W, h, wf

Update Report
 Real time Update

Output Variables... Options... New Report Apply Trace Add Trace Close

Message Manager

- Interpolating frequency sweep complete. Converged. (3:09:08 PM Apr 16, 2020)
- Normal completion of simulation on server: Local Machine. (3:09:08 PM Apr 16, 2020)
- HFSSDesign1: Solutions have been invalidated. Undo to recover. (3:22:37 PM Apr 16, 2020)
- Adaptive Passes did not converge based on specified criteria. (3:23:26 PM Apr 16, 2020)

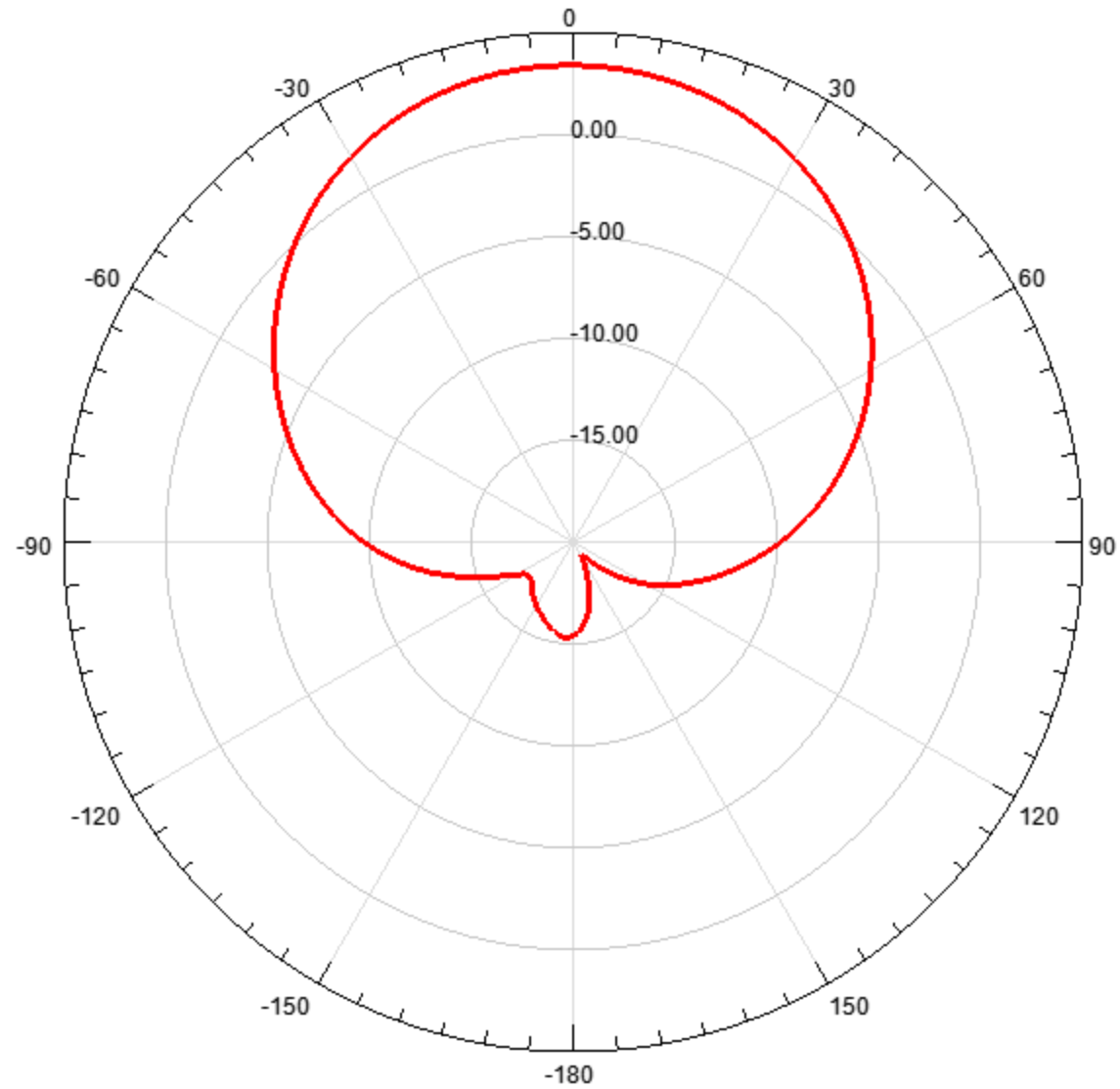
Ready

Hide 15 Messages Hide Progress Ang 104.0111 Mag 33.2179

3:31 PM 4/16/2020

Test: H-Pattern

Gain Plot 3



HFSSDesign1

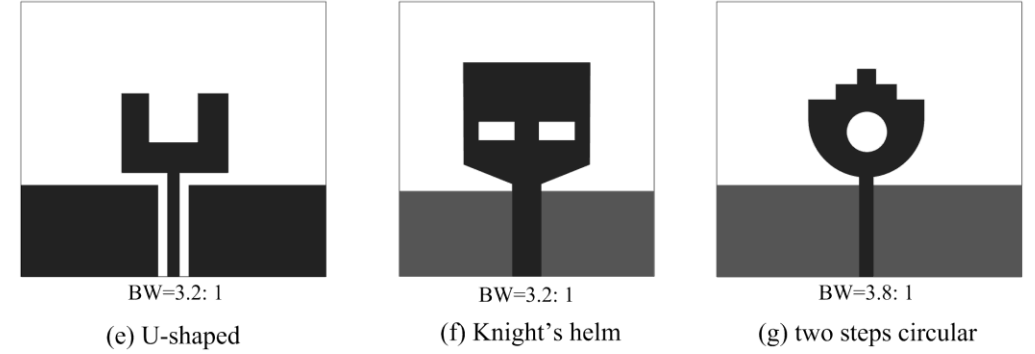
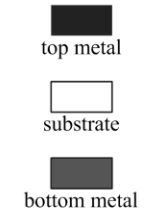
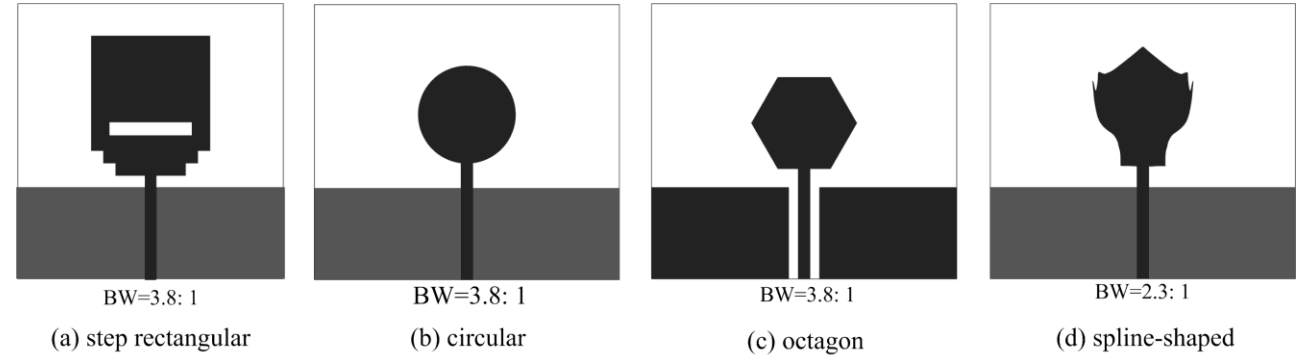
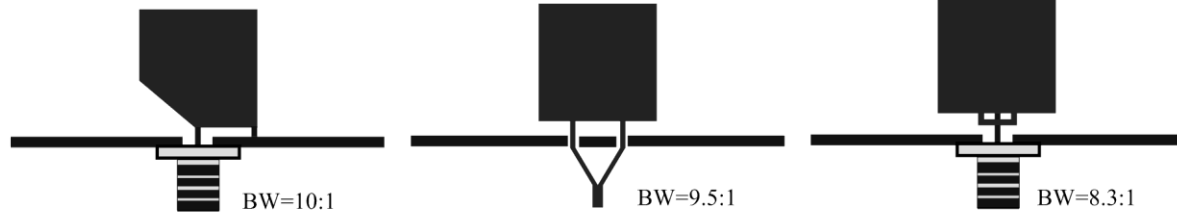
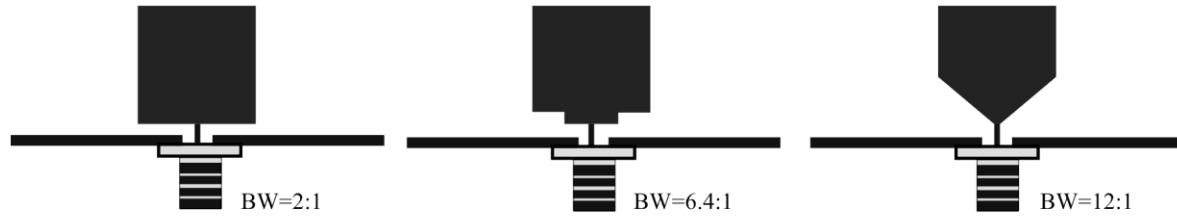
Curve Info	
—	dB(GainTotal)
Setup1	: LastAdaptive
Freq=2.45GHz	Phi=90deg

SQUARE PLANAR MONOPOLE ANTENNA

Square Planar Monopole Antenna

- 1991 yılında Honda tarafından düzlemsel bir disk tekel anteni incelendi.
- Japon televizyonları için bu anteni (90-770 MHz) geliştirdi.
- 1992'de tüm S, C, X ve Ku bantları için geri dönüş kaybı 10 dB'den fazla olan, yani 1:18 bant genişliği olduğunu bildirdi.
- Düzlemsel bir monopol, geleneksel bir monopolün tel elemanının bir düzlemsel eleman ile değiştirilmesiyle gerçekleştirilir.
- Kare olan düzlemsel eleman, bir toprak düzleminin üzerine yerleştirilir ve bir SMA konektörü kullanılarak beslenir.

Monopole Antenna Types



Square Planar Monopole Antenna

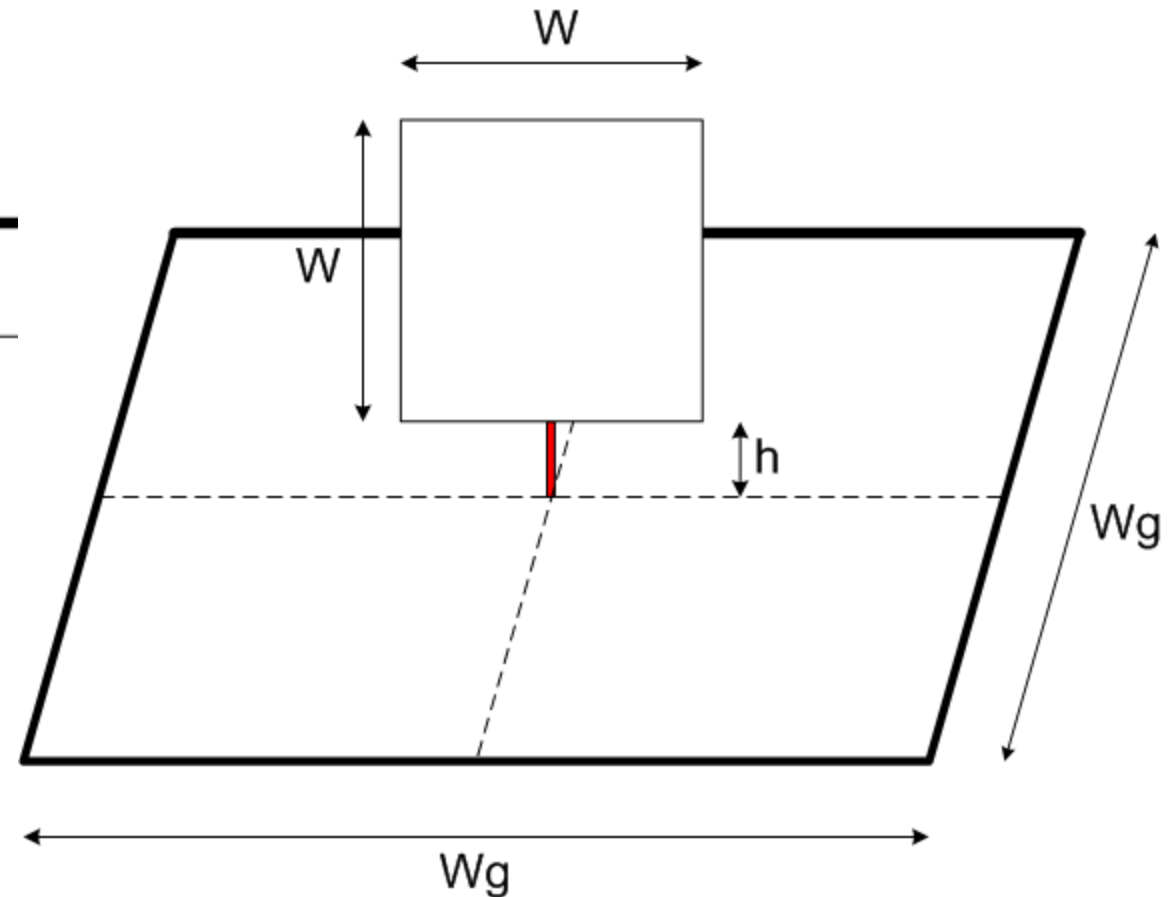
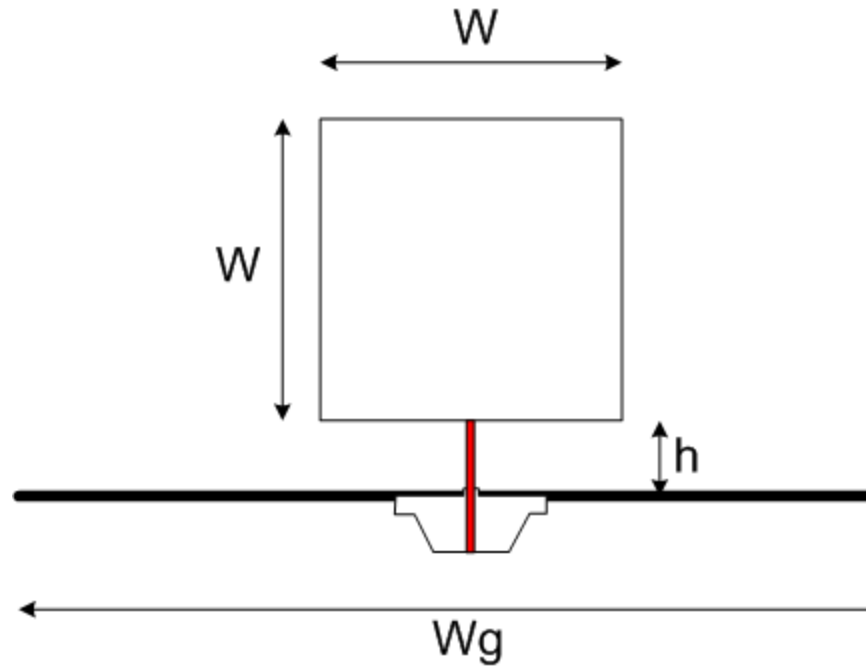
$$\lambda = \frac{c}{f}$$

$$W = 0.3\lambda$$

$$W_g = \lambda$$

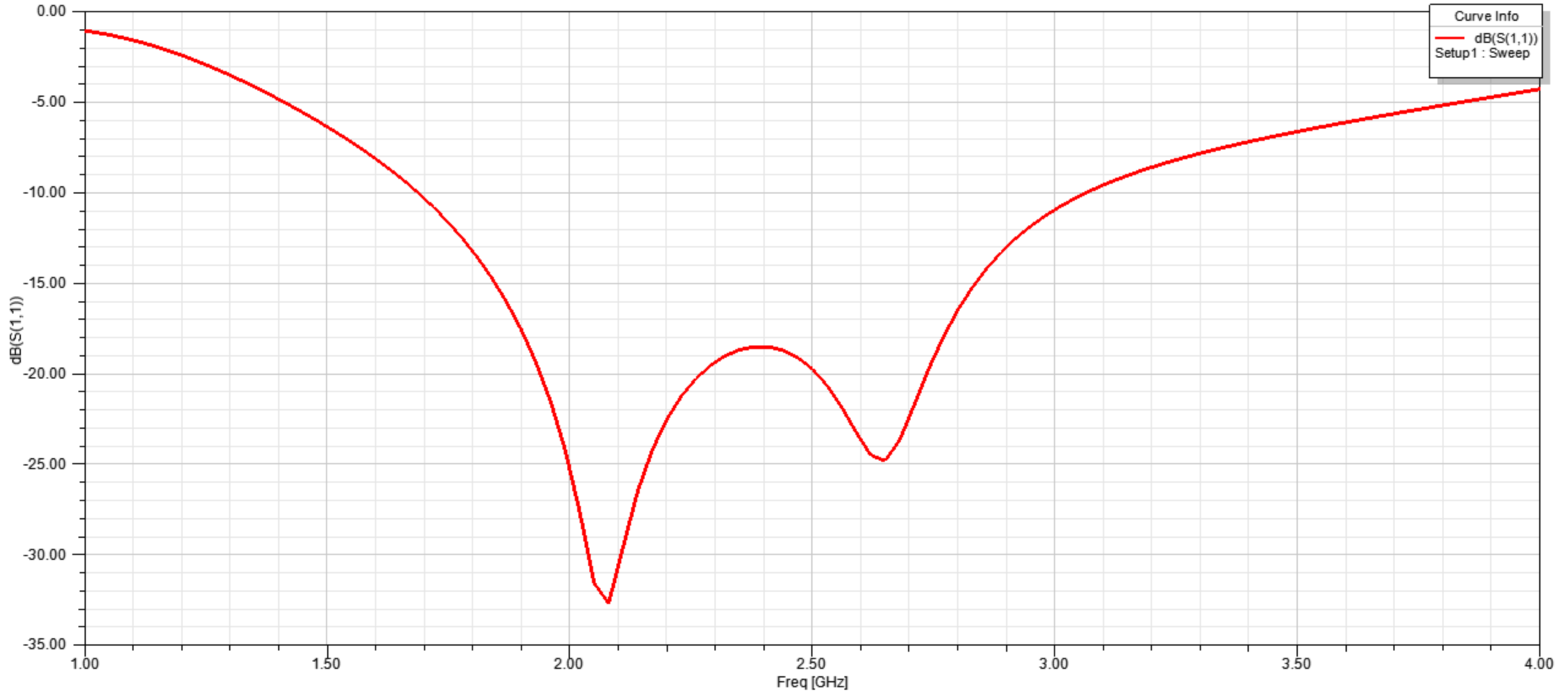
$$h = 0.02\lambda$$

Konnektör çapı 0.01λ alınır.

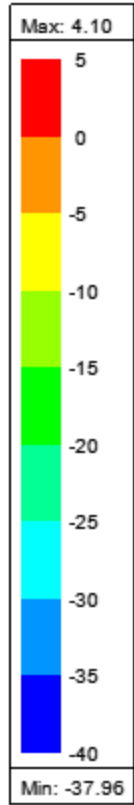


S Parameter Plot 1

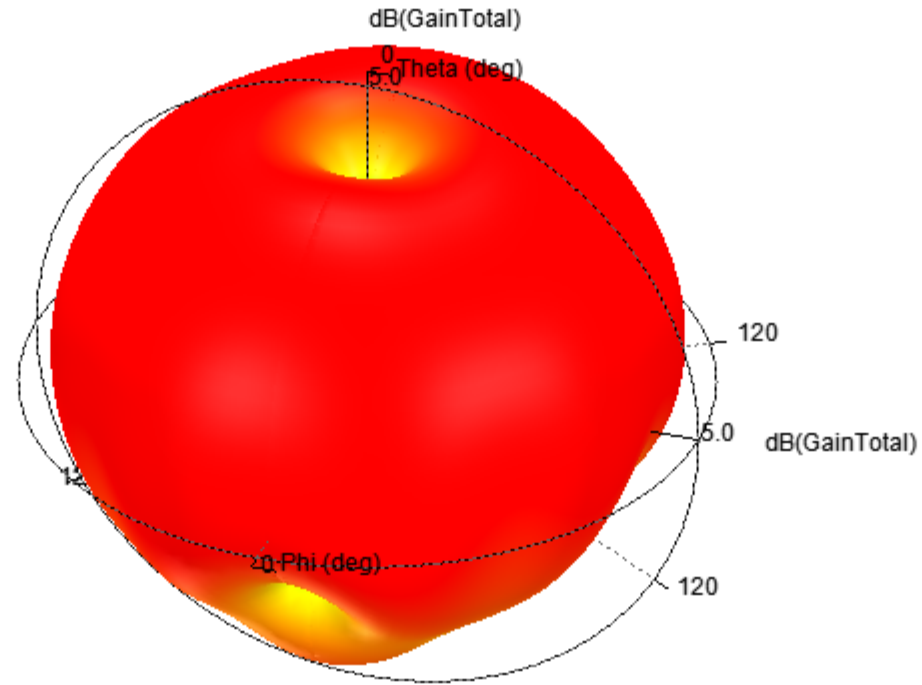
HFSSDesign1 



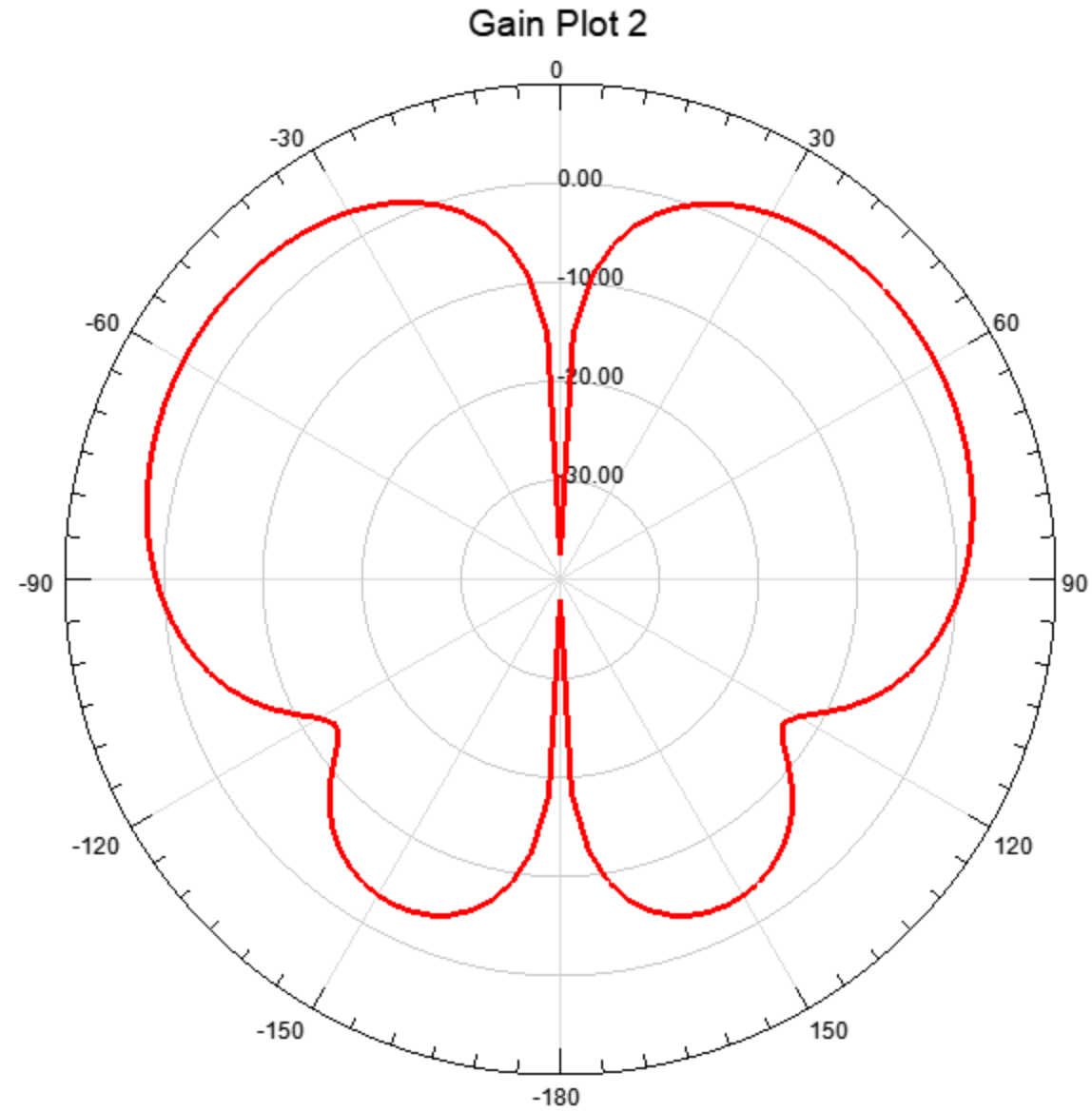
Gain (Far Field report – 3D Polar Plot)



Gain Plot 1



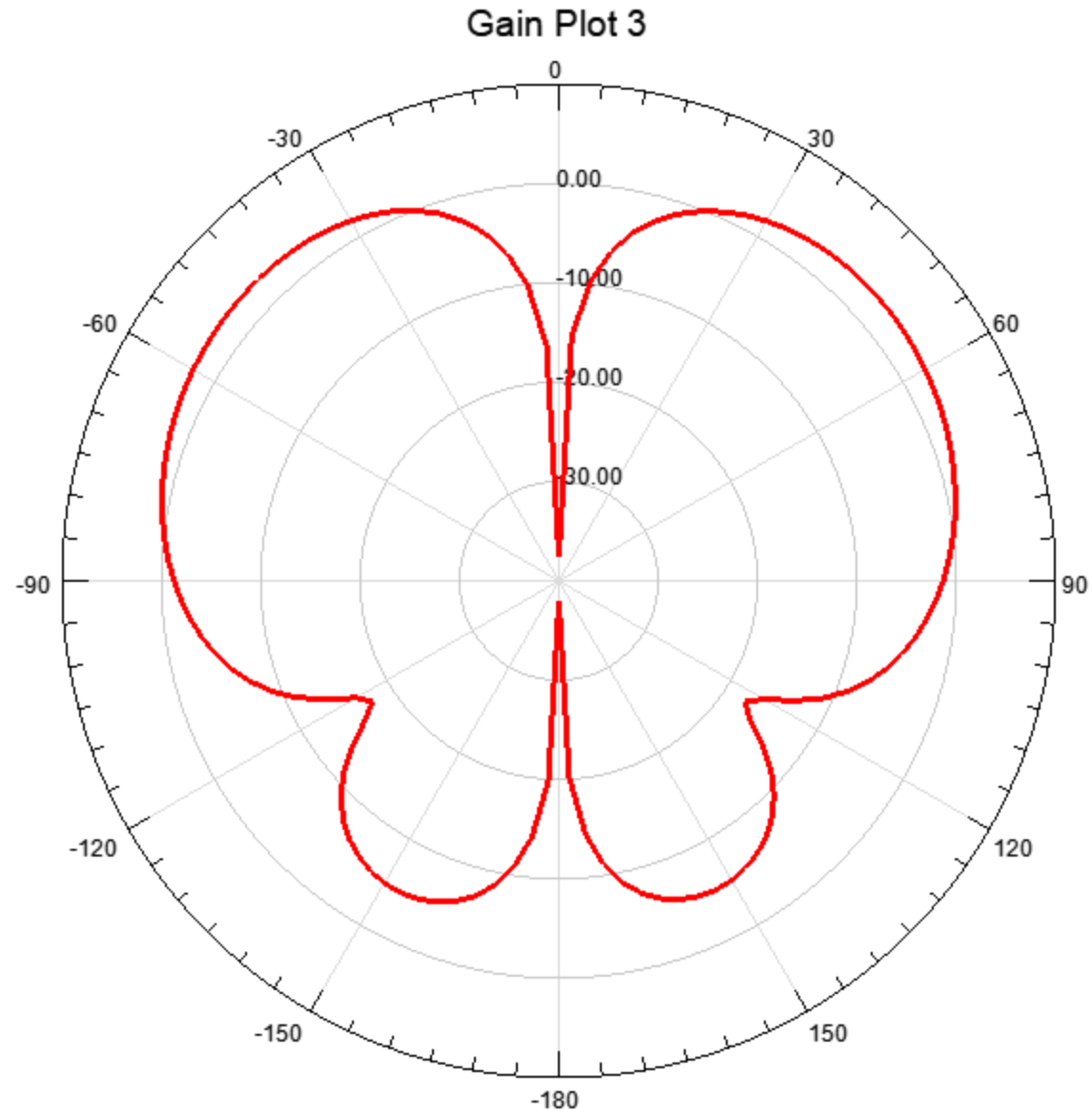
E-Pattern (90derece)



HFSSDesign1

Curve Info	
—	dB(GainTotal)
	Setup1 : LastAdaptive
	Freq='2.45GHz' Phi='0deg'

H-Pattern (0 derece)



HFSSDesign1

Curve Info

— dB(GainTotal)
Setup1 : LastAdaptive
Freq=2.45GHz' Phi='90deg'

Dipole Antenna

Dipole Antenna Design

$$\lambda = \frac{c}{f}$$

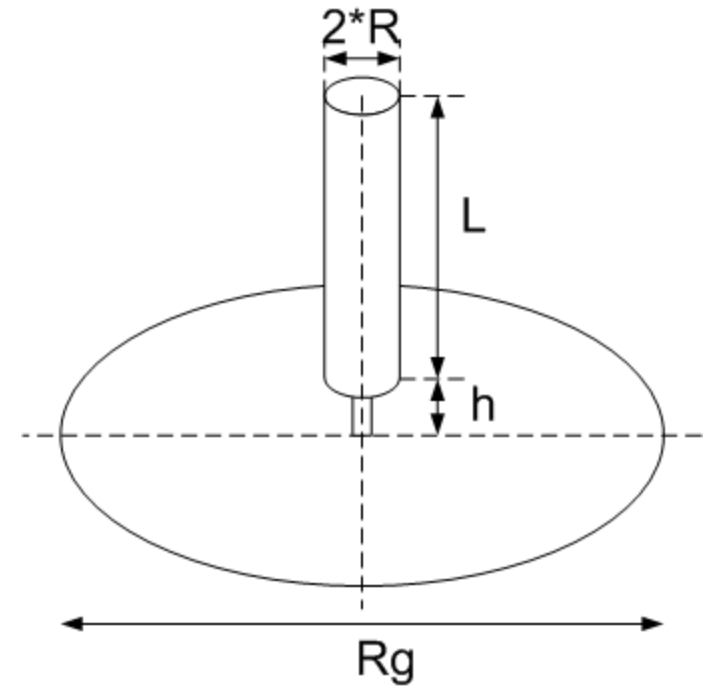
$$L = 0.675\lambda$$

$$R = 0.004\lambda$$

$$R_g = \lambda$$

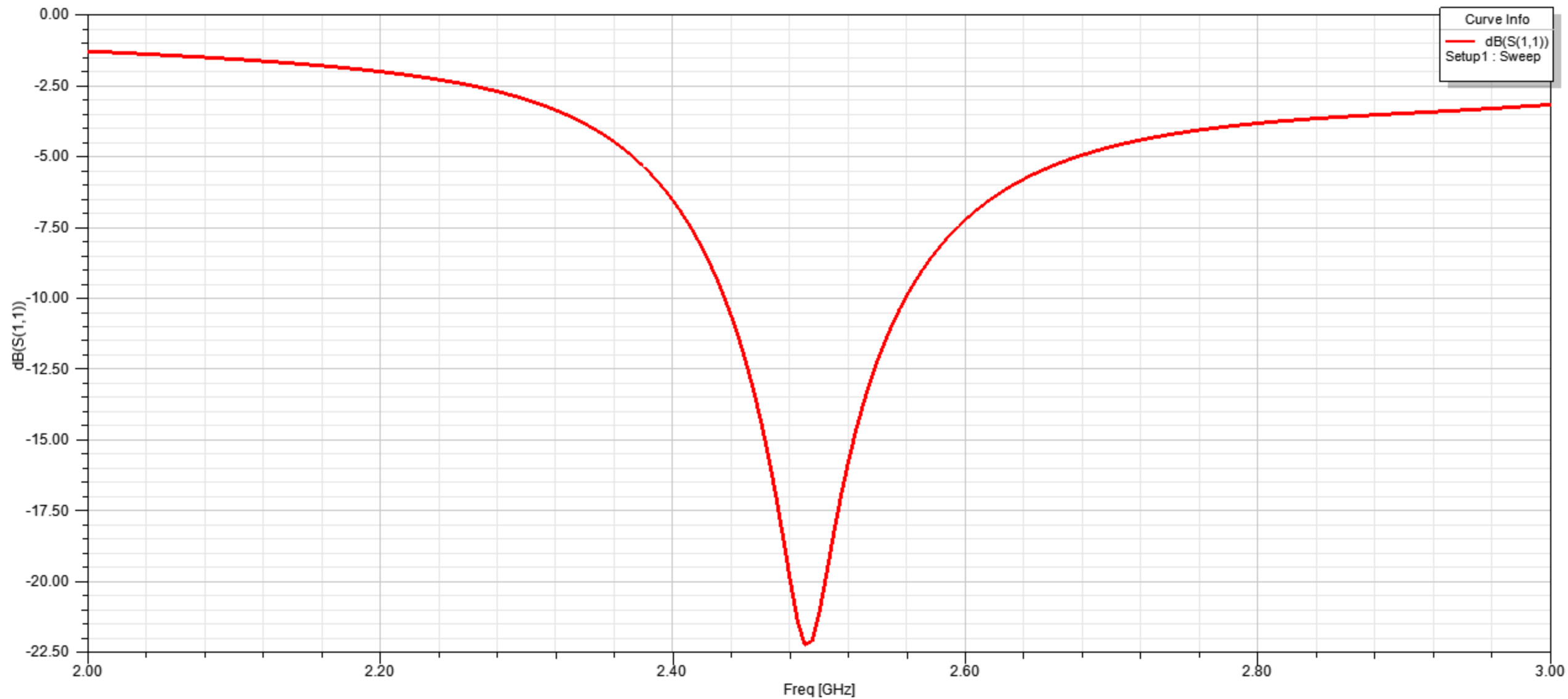
$$h = 0.02\lambda$$

Konnektör çapı 0.01λ alınır.

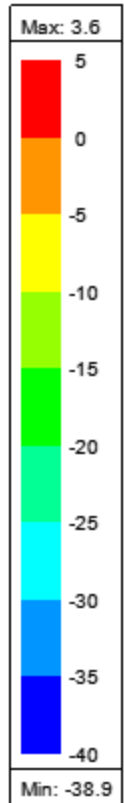


S Parameter Plot 1

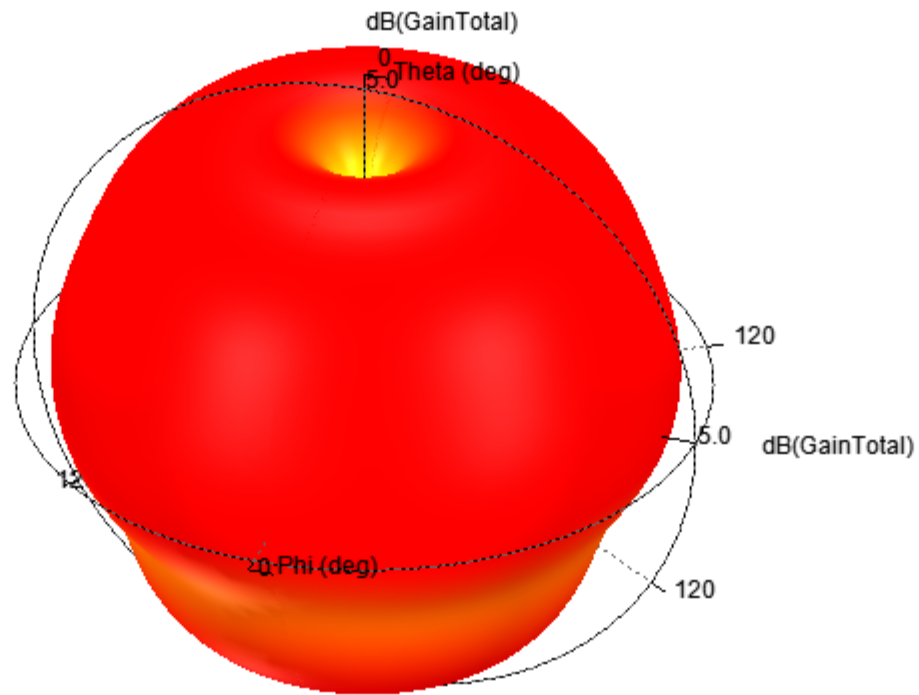
HFSSDesign1 



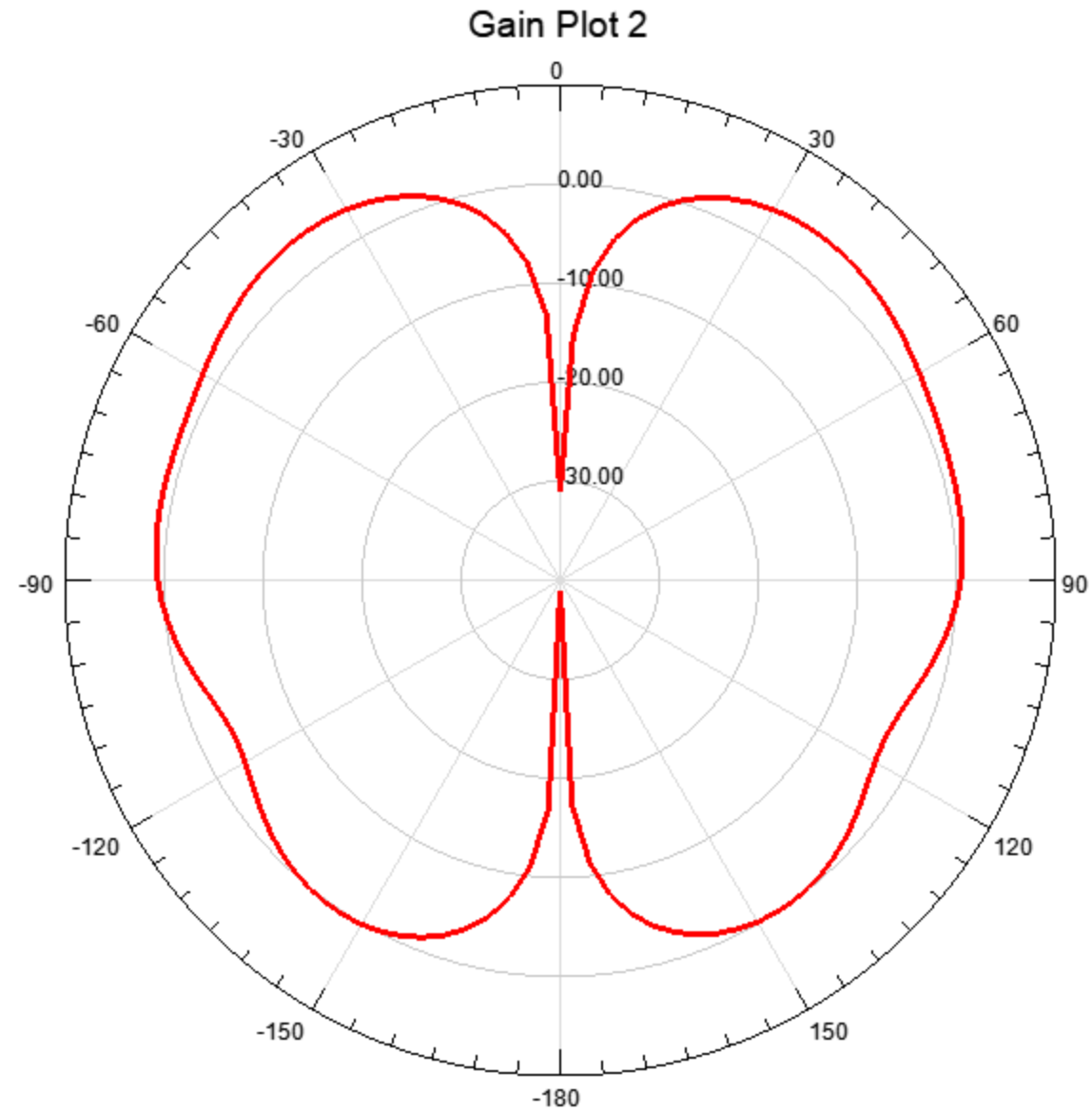
Gain (Far Field report – 3D Polar Plot)



Gain Plot 1



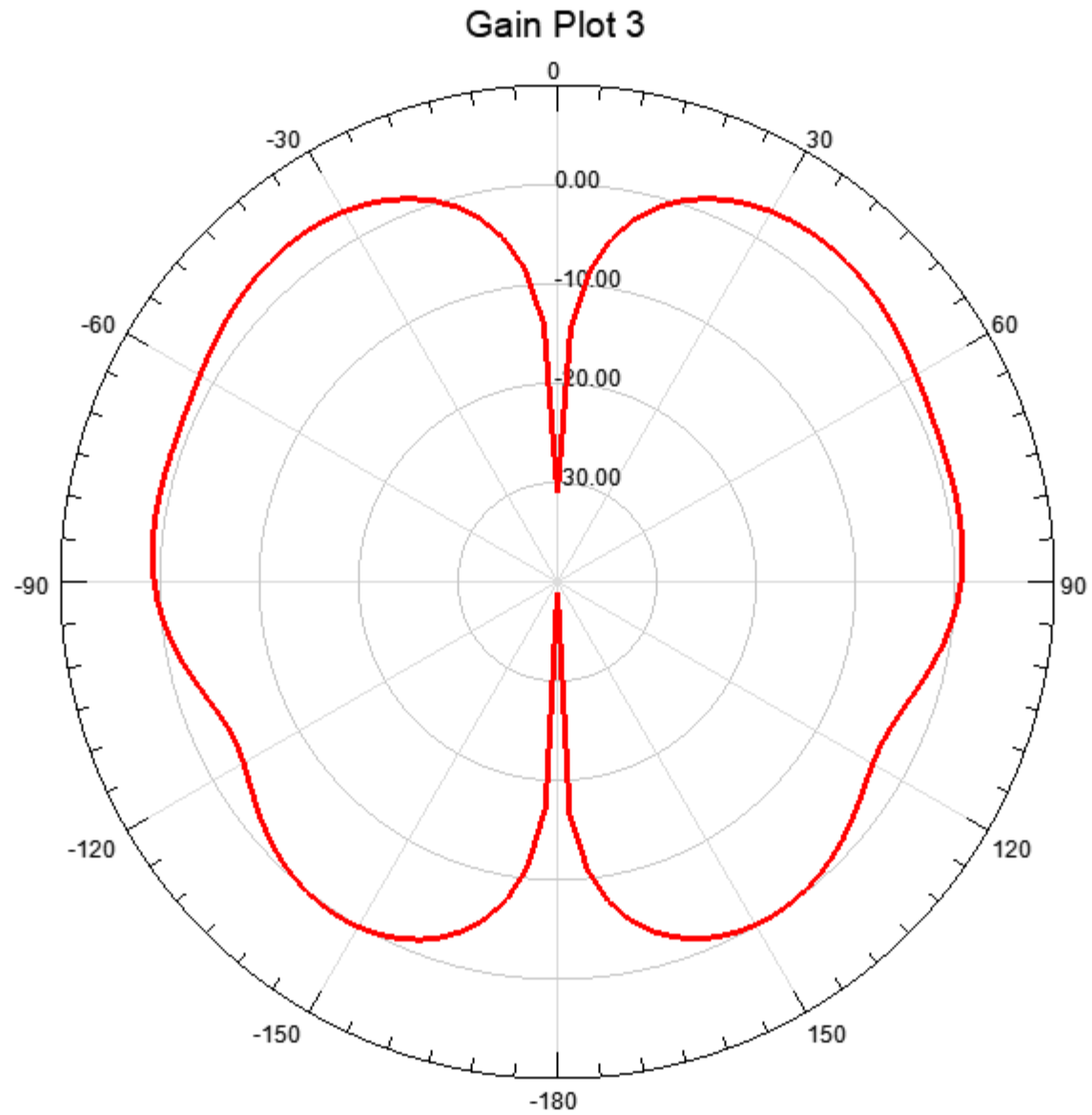
E-Pattern (90derece)



HFSSDesign1

Curve Info	
—	dB(GainTotal)
Setup1 : LastAdaptive	
Freq=2.45GHz' Phi=0deg'	

H-Pattern (Oderece)



HFSSDesign1

Curve Info	
—	dB(GainTotal)
Setup1 : LastAdaptive	
Freq=2.45GHz' Phi=90deg'	

Anten Parametreleri Ölçümü:

Işıma Paterni

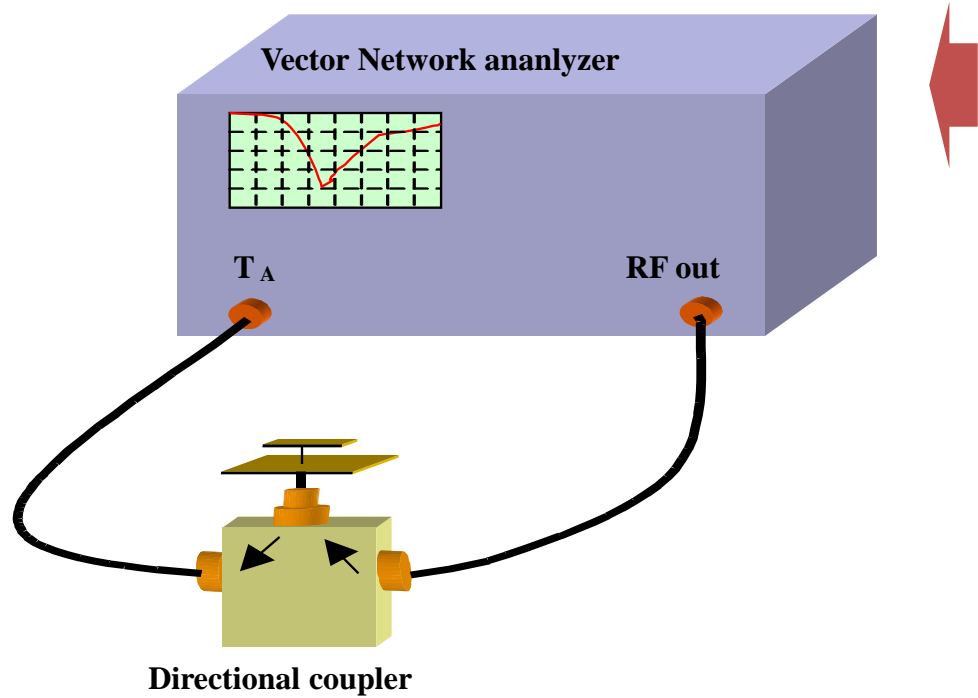
S11-Return Loss, VSWR

Gain

Konnektör Tipleri

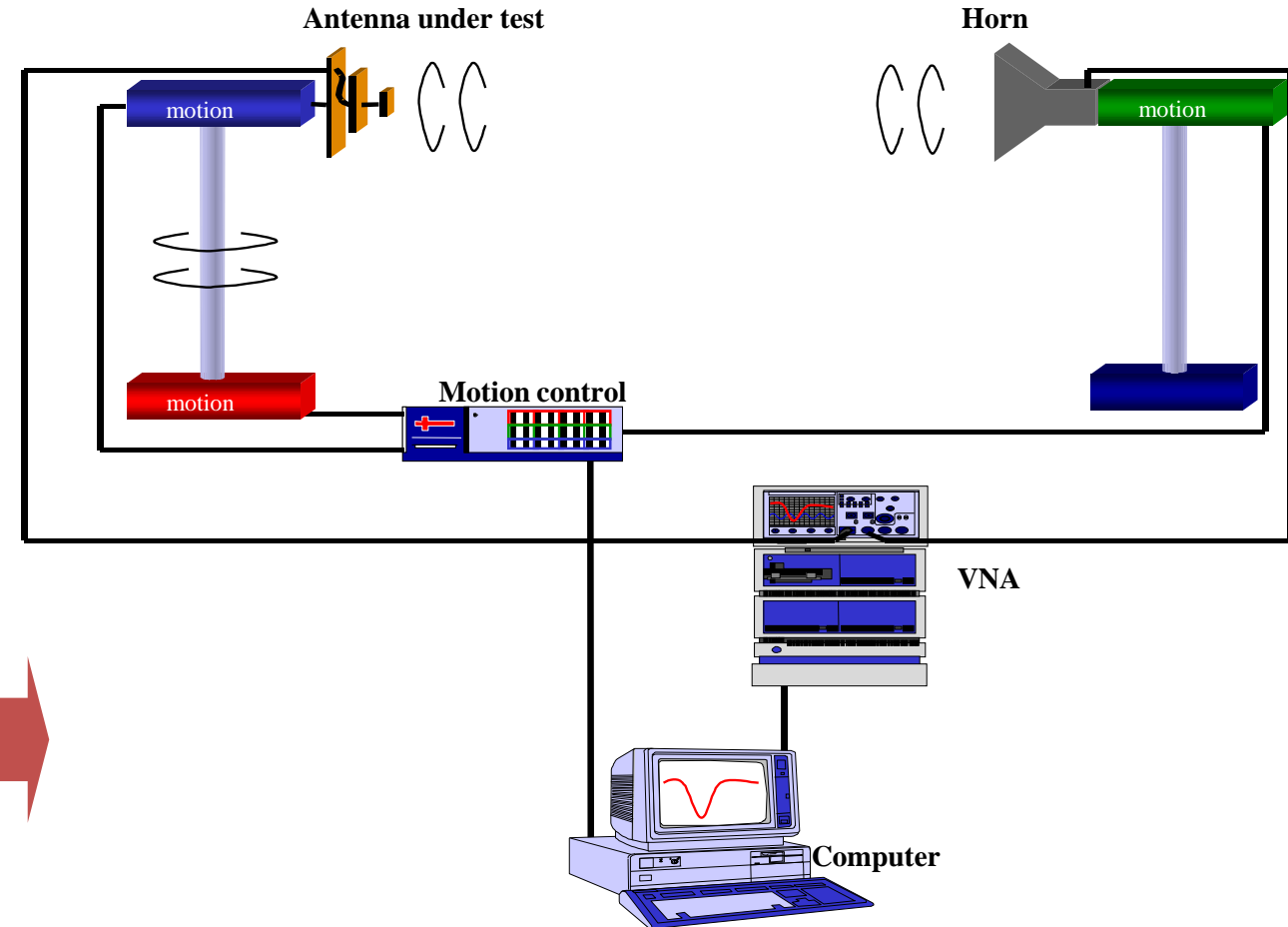


Measurement methods

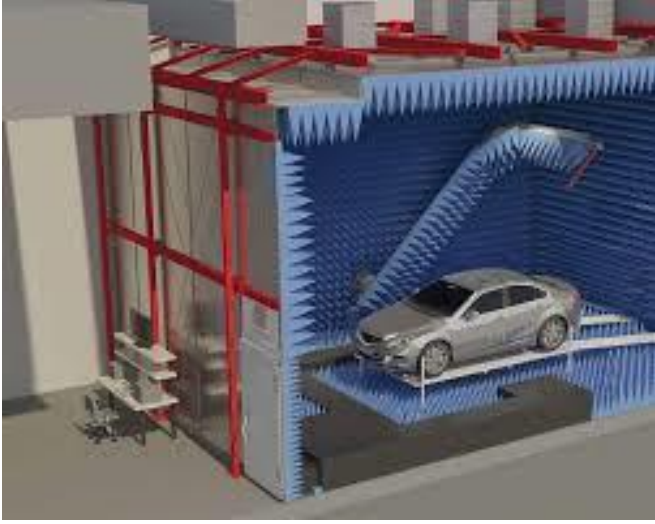


Radiation measurements

Impedance matching measurements



Yansımaz Oda



Radome

- Bu nedenle, anten sistemini havanın bu olumsuz etkilerinden, dış erişim tehditlerinden korumak için radom kullanılır.
- Radom, anten üzerinde olumsuz etkiler yaratan toz, su, su buharı, rüzgar, böcekler, partiküller, güneş radyasyonu, vs.den anteni korur. 250 km/saat rüzgar hızına dayanabilmelidir.
- Radomun iç sıcaklığı $-50 - +60^{\circ}\text{C}$ olması durumunda çalışabilmelidir. Isıtma yapılacaksa tamamen kuru havayla yapılmalıdır. Radom üzerine çok yağış düştüğünde antenin düşeydeki polarizasyonu kaybolur.
- Önemli olan kılıfta kullanılan malzemenin elektromanyetik dalgaların geçişine olabildiğince uygun olmasıdır.
- Bu yapının adı RAdar DOME (yani radar-kubbe) kelimelerinden türetilmiştir.
- Bu koruyucu kaplama, elektromanyetik dalgaları olabildiğince az yansıtmalı, soğurmalı (absorbtion), kırmalı (diffraction) veya saçmalıdır (scattering) ve geçiş kayıpları yine olabildiğince az olmalıdır.
- Dieltrik malzemedede yapılmalıdır. İletken olamaz. Polypropilen
- Bir radomda dalgaların, hem gidiş ve hem de geliş yönündeki zayıflama oranları aynı olmalıdır. Bu nedenle bir „Çift Yönlü Zayıflama” söz konusudur. Bu Çift Yönlü Zayıflama değeri köpüklü bir malzemedden yapılmış bir radomda tipik 0,3 dB civarındadır, yani bu yüksek frekanslı enerjide yaklaşık bir toplam %7 lik kayba karşılık gelir. Radar denklemine göre ise bu yaklaşık %2 lik bir menzil kaybı demektir.
- Uçağın burnunda rüzgarı ilk karşılayan bölge olan radom, radar antenlerinin üzerine yapılan kaplama olarak özetlenebilir. Radom, uçağa aerodinamik bir özellik kazandırır.
- Ayrıca hızlı bir şekilde dönen antenler sayesinde yakındaki personeli kazara çarpmalara karşı korurlar.

Radome

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Kaynaklar

- <https://www.ece.ucsb.edu/~long/ece145a/ampdesign.pdf>
- Amplifiers, Prof. Tzong-Lin Wu. EMC Laboratory. Department of Electrical Engineering. National Taiwan University

Usage Notes

- These slides were gathered from the presentations published on the internet. I would like to thank who prepared slides and documents.
- Also, these slides are made publicly available on the web for anyone to use
- If you choose to use them, I ask that you alert me of any mistakes which were made and allow me the option of incorporating such changes (with an acknowledgment) in my set of slides.

Sincerely,

Dr. Cahit Karakuş

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