COMMUNICATIONS PROJECT

Antenna Types

Homework Results

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Homework Tasks

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HW5)

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1)
- familiarize with antennas and antenna types (textbooks, wiki etc.)

2)
categorize and briefly summarize antenna types and their properties (gain, beam
width, band width, impedance, characteristic sizes)

- single antennas: (nearly) omni-directional, directional (yagi, patch, parabolic
dish)

- antenna groups (co-linear, antenna arrays)

include examples of corresponding radiation pattern
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1 Some Definitions

Antenna A device which translates guided electromagnetic waves on a transmission line to waves in free space (and vice versa).

Radiation Pattern F The distribution of power (intensity) radiated from an antenna as a function of direction, in spherical coordinates (azimuth ϕ, elevation θ). Usually normalized to its maximum value.

Directivity D The power density as a function of direction normalized to the average power density of all directions. Antenna specifications typically give the directivity as peak directivity for all directions. It will determine how much more power the antenna radiates in its peak direction compared to an isotropic reference antenna.

Gain G Is similar to the directivity in that it describes the power density in the preak direction with reference to that of an isotropic antenna but it also takes into account losses. Especially relevant with electrically short antennas.

Beamwidth For directional antennas, the angle from the peak of the main lobe of the radiation pattern to the point at which the radiated power density decreases by a specified factor, typically 50 % or -3 dB (Half Power Beam Width, HPBW).

(Feedpoint-)Impedance The relationship between the voltage and current at the input of the antenna (complex number). Typically for resonant antennas, the reactive part should be close to zero and the impedance should stay constant in the desired frequency band and matched to the feeding transmitter to allow for a low reflection coefficient.

Polarization Direction of the electric (and magnetic) field oscillation over time. If it stays constant, the field is said to be linearly polarized. The direction can also change if the electric field can be decomposed into components that are out of phase by 90 °. If the amplitude of these components is the same, the field is called cirularly polarized. If it is different, it is called eliptically polarized.

Antenna Arrays A collection of antennas that forms a combined radiation pattern. Often, the antennas can be driven individually to provide each with a different phase angle.

2 Antenna Types

The following table 1 shows a few antenna examples with characteristic numbers. Some radiation patterns for can also be seen in the figures below. Most of these characteristics are dependent upon the antenna geometry and are therefore only rough typical values.

Name	D (dB)	3 dB-Beamw.	Impedance	Bandwidth	Polarization	Typical Sizes
(nearly) omni-dir.						
$\lambda/2$ Dipole	2.15	$\approx 80\,^\circ$	$73\,\Omega$	narrow	linear	$\lambda/2$
$\lambda/4$ Monopole	5.2	$\approx 40\,^\circ$	$36.5\,\Omega$	narrow	linear	$\lambda/4$
directional						
Patch	5...8	typ. $65\,^\circ$	$50..300\,\Omega$ [1]	narrow	linear	some 10 mm
Helix (Axial-Mode)	8...14	$\frac{5}{2}\frac{C}{\lambda}\sqrt{\frac{N\cdot S}{\lambda}}$ [2]	$\approx 140 \cdot C/\lambda$	narrow	elliptical	50 mm...few m
Horn	10...20	$11\,^\circ$...$15\,^\circ$	$50\,\Omega$ [3]	wide	linear	50...400 mm
Yagi	...20	$30\,^\circ$...$70\,^\circ$	$10...40\,\Omega$	narrow	linear	< 10 m
Parabolic	10...40	$\approx 70\lambda/D\,^\circ$ [4]	depends [5]	wide	depends [6]	0.5...500 m [7]
antenna groups						
2x2 Patch Array	$>$ patch	$\approx 15\,^\circ$	$50\,\Omega$	narrow	linear	some 10 mm
Collinear Dipoles	$10 \cdot \log n$ [8]	$\propto 1/n$	$73\,\Omega/n$	narrow	linear	$n \cdot (\lambda/2 + s)$

[1] depends on patch width
[2] C: circumference of one turn, N: number of turns, S: axial pitch between turns
[3] can be matched to waveguide geometry
[4] D is the aperture diameter
[5] depends on feed antenna
[6] depends on feed antenna
[7] see FAST radio telescope
[8] n : number of elements, gain relative to single element

Table 1: Compilation of different antenna types.

Name	Typical Uses
Dipole	fixed-frequency, omnidirectional applicatins, e.g. WiFi routers
Monopole	mobile devices, vehicles
Patch	PCBs and ICs
Helix	where circular polarization is needed, e.g. certain space communication
Horn	waveguides, feed for parabolic antennas, low-loss applications
Yagi	terrestrial communication, fixed-frequency applications
Parabolic	satellite communication links, radio telescopes
Arrays	interferometry, beamsteering applications

Table 2: Typical antenna application areas.

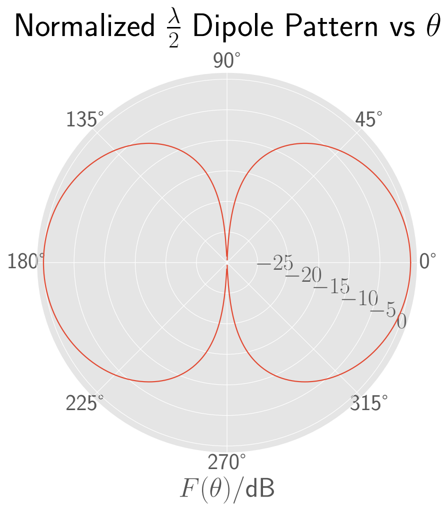

Figure 1: $\lambda/4$ Dipole characteristic in the elevation plane. Antenna axis lies vertically.

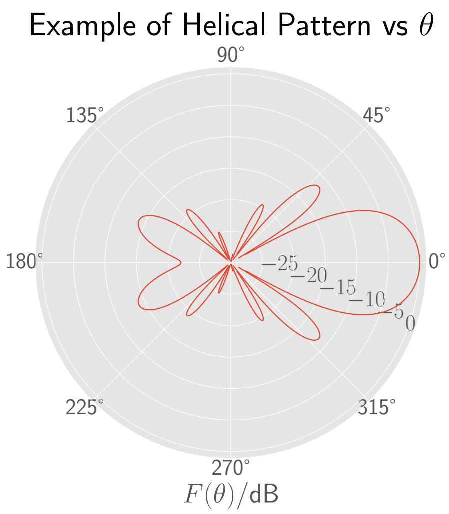

Figure 2: Helical characteristic in the elevation plane. Separation: 0.22 m, Number of turns: 10, Frequency: 500 MHz ($\lambda = 0.6$ m)

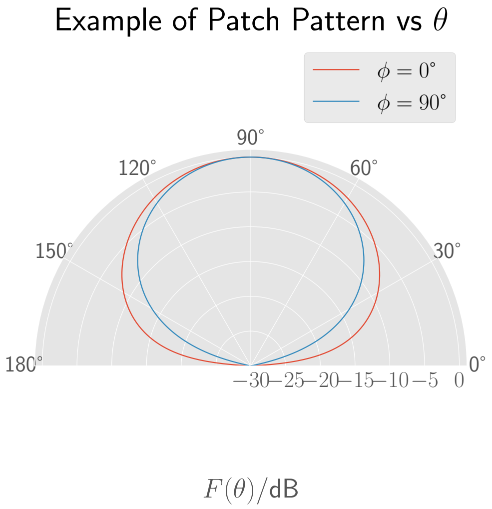

Figure 3: Single Patch characteristic in the elevation plane for two different ϕ angles. $W = L = 0.5\,\lambda$.

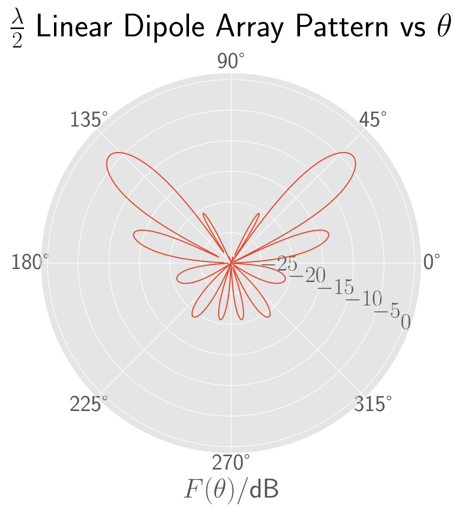

Figure 4: Characteristic of equally spaced linear dipole array in the elevation plane. $N = 8$, Separation: $\lambda/2$

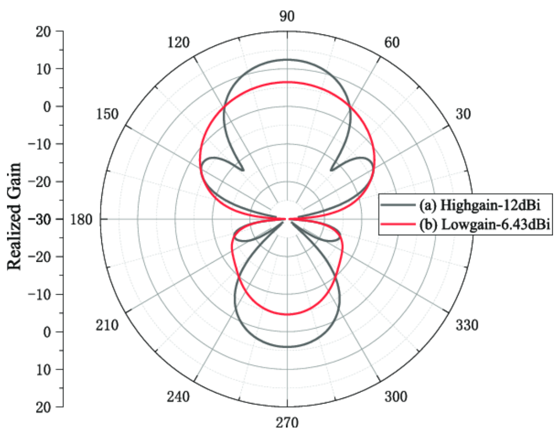

Figure 5: Example of a Yagi-Uda characterisitic. Taken from https://www.researchgate.net/figure/Radiation-patterns-of-two-Yagi-Uda-antennas-a-with-high-gain-and-b-with-low-gain_fig2_363745716 under CC BY-NC-ND 4.0

Figure 6: Drawing of a typical Yagi-Uda antenna.

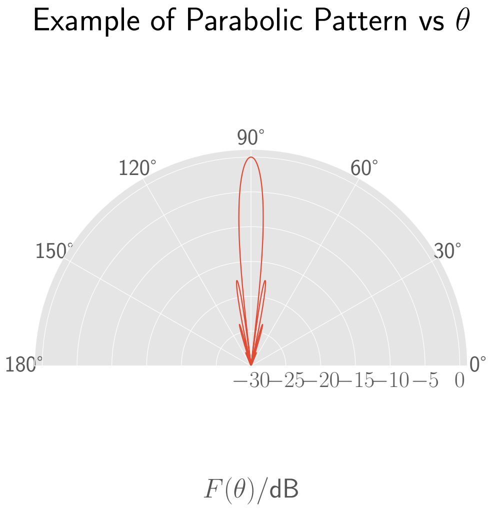

Figure 7: Example of Parabolic characteristic for $D = 10\lambda$.

Figure 8: Satellite communications parabolic antenna. Taken from https://en.wikipedia.org/wiki/Parabolic_antenna#/media/File:Erdfunkstelle_Raisting_2.jpg under CC BY-SA 2.5

References

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[7] Stan Gibilisco. *Gain of a Collinear Antenna Array*. 2015. URL: https://www.youtube.com/watch?v=DFRe7ttChwc (visited on 05/23/2023).