YAGI-UDA ANTENNA

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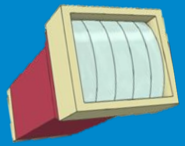

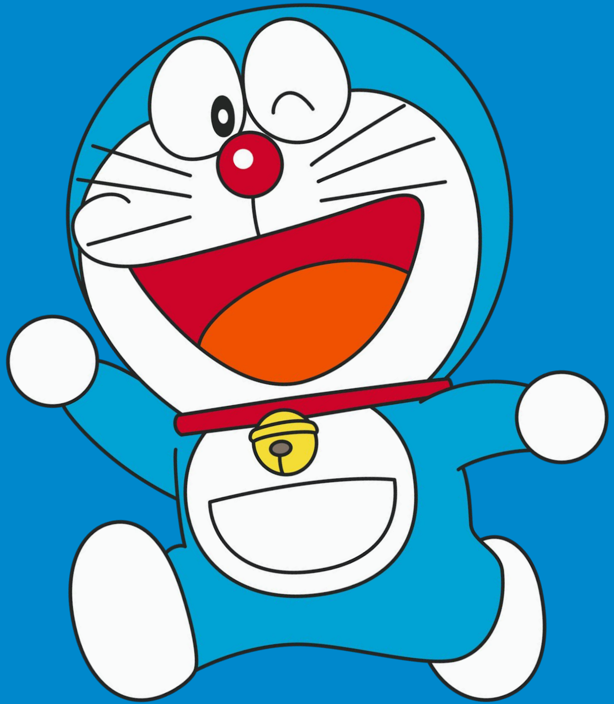

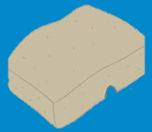

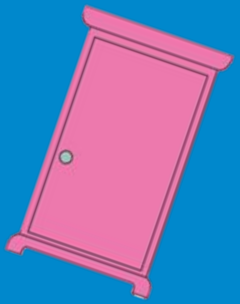

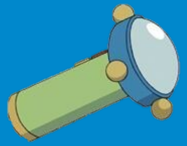

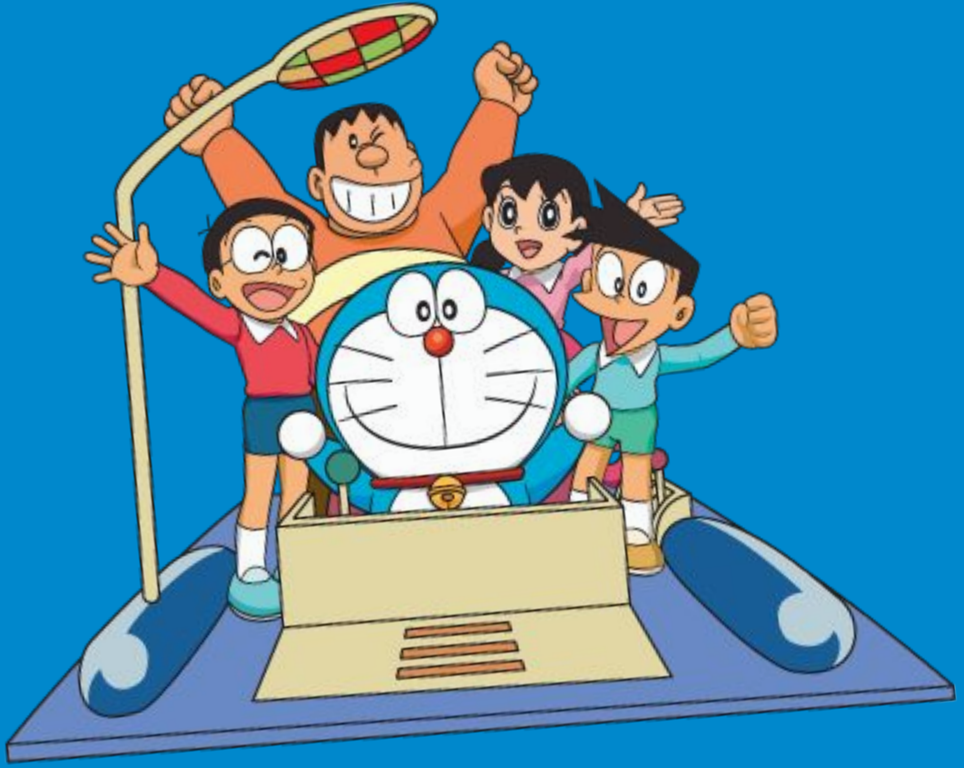

1. Introduction
2. Structure
3. Mathematical Designs
4. Properties
5. Applications
6. Conclusion

Definition

"An **antenna** is a metallic structure that captures and/or transmits radio electromagnetic waves"

-From Nasa website-

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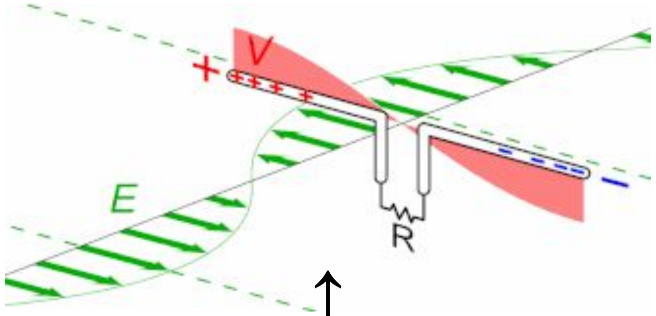
Types of antenna

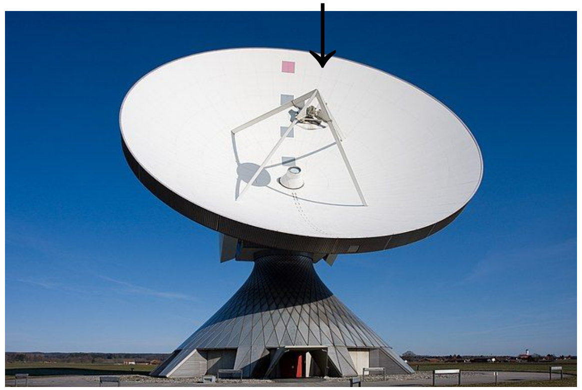
Different type of antenna base on the design of the antena

← Helical antennas



↑
Dipole antenna

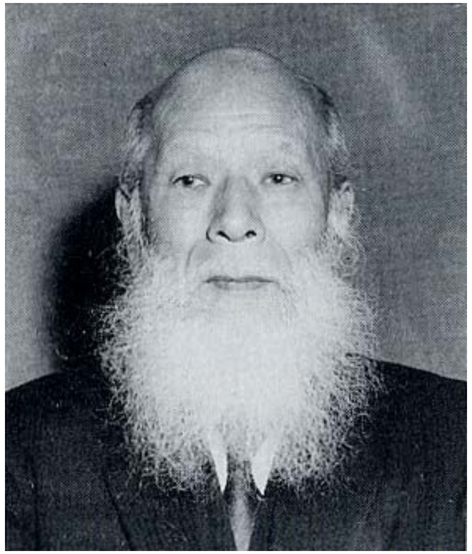
Parabolic antenna
↓



And many more…

Yagi - Uda

- Invented in **1926** by **Shintaro Uda** with the guidance of **Hidetsugu Yagi**
- **Directional** antenna comprising an array of <u>several parallel elements in a line</u>



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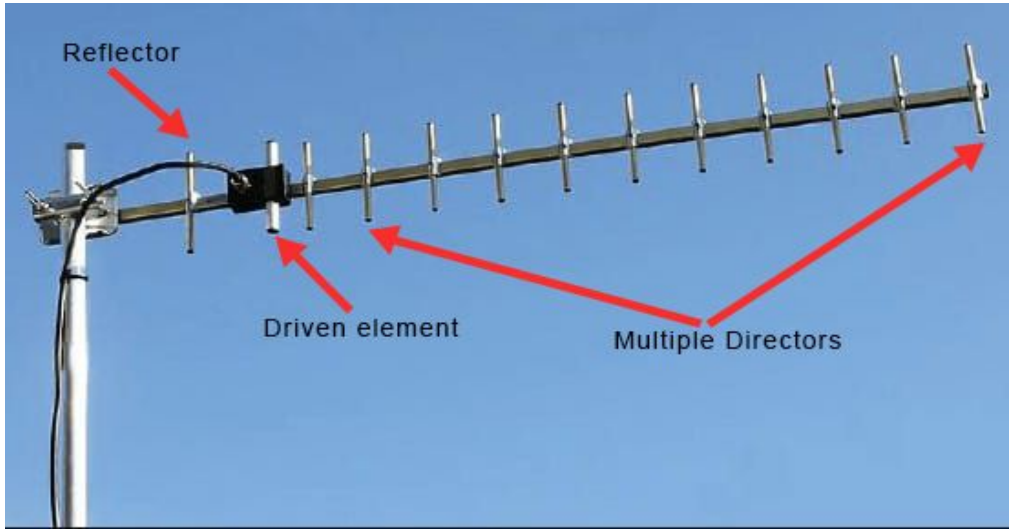
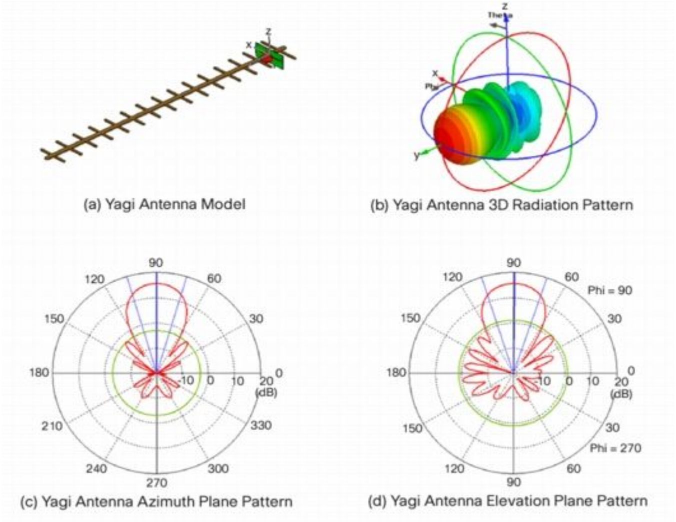
Yagi - Uda

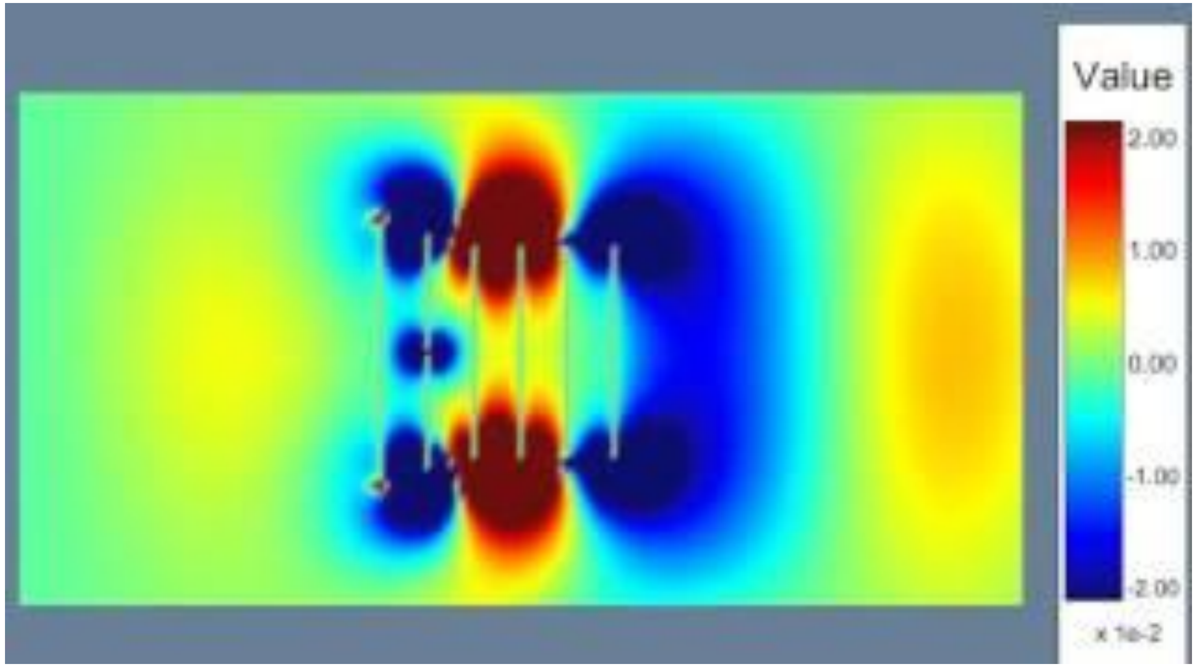
- A directional antenna designed to focus radio waves in a specific direction.
- Composed of multiple metallic elements arranged in a linear fashion.
- Key elements (component):
    - **Driven**: Central element, often a half-wave dipole, that actively transmits or receives signals. <u>(Active element).</u>
    - **Directors**: Placed in front of the dipole, progressively shorter in length
    - **Reflector**: Located behind the dipole, typically longer than the dipole itself.



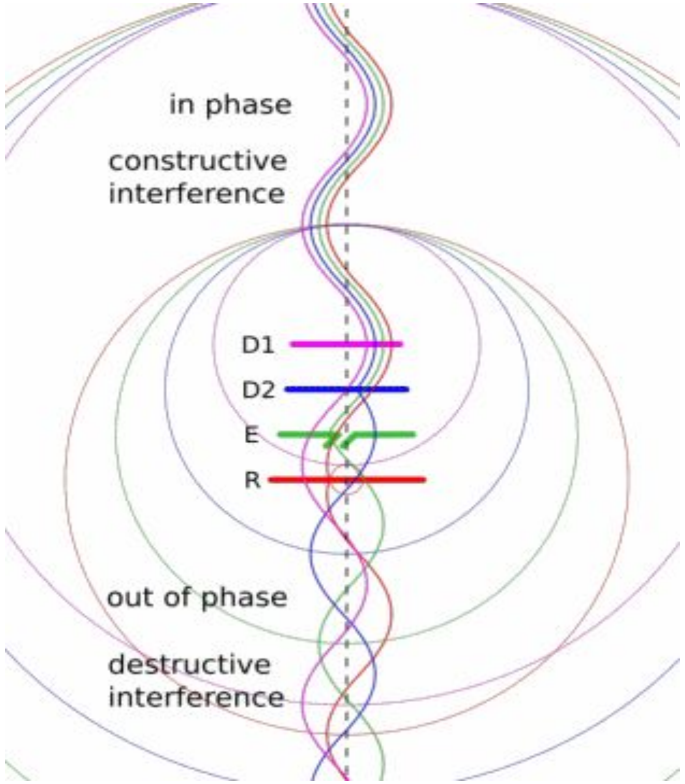


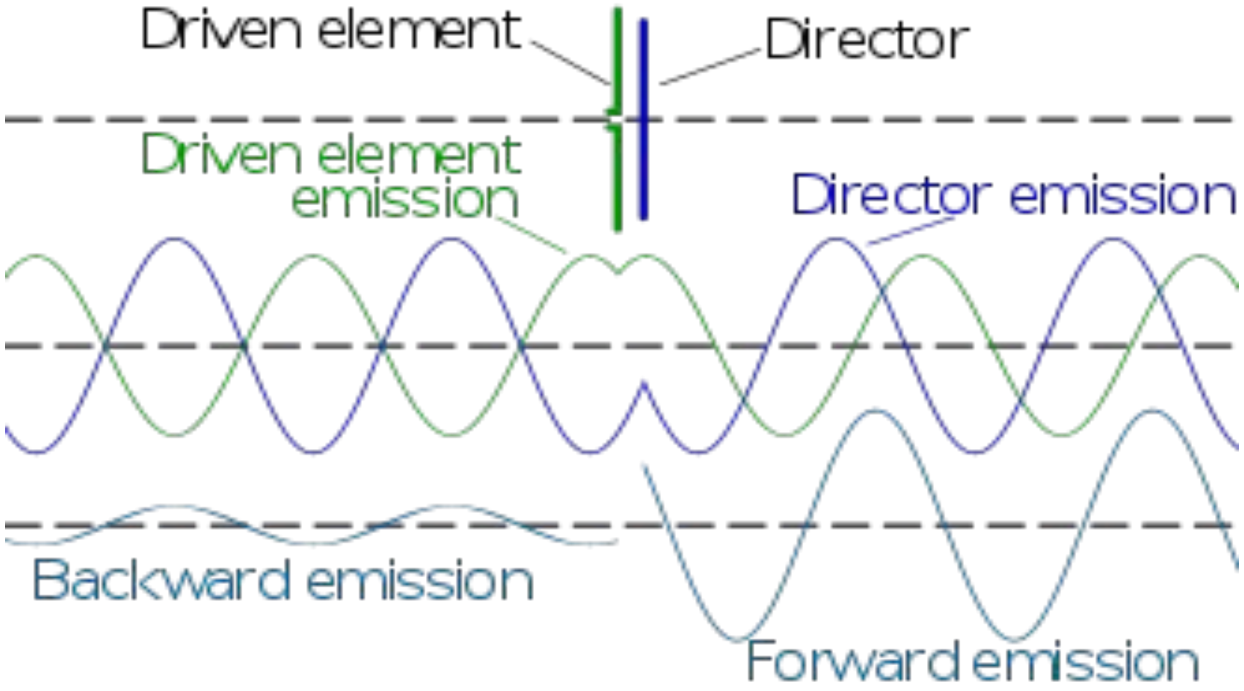
Working principle

- The combination of elements creates constructive interference in the desired direction, strengthening the signal.
- Destructive interference occurs in other directions, minimizing unwanted signals.
- This focused energy leads to better reception or transmission compared to omnidirectional antennas.



Analysis


in phase
constructive interference
D1
D2
E
R
out of phase
destructive interference


Driven element
Director
Driven element emission
Director emission
Backward emission
Forward emission

Characteristic

There are no Universal formula for any character of the Yagi-Uda Antenna

Approximation:

The antenna gain of the Yagi antenna is greatly dependent on the dipole gain and the number of elements and is given by *(Ochalaand Okeme, 2011):*

Gain: G = 1.66*N

Where: G is gain of antenna

1.66 is the dipole gain

N is the number of elements

Current on element n *(Ankit Agnihotri, 2013)*

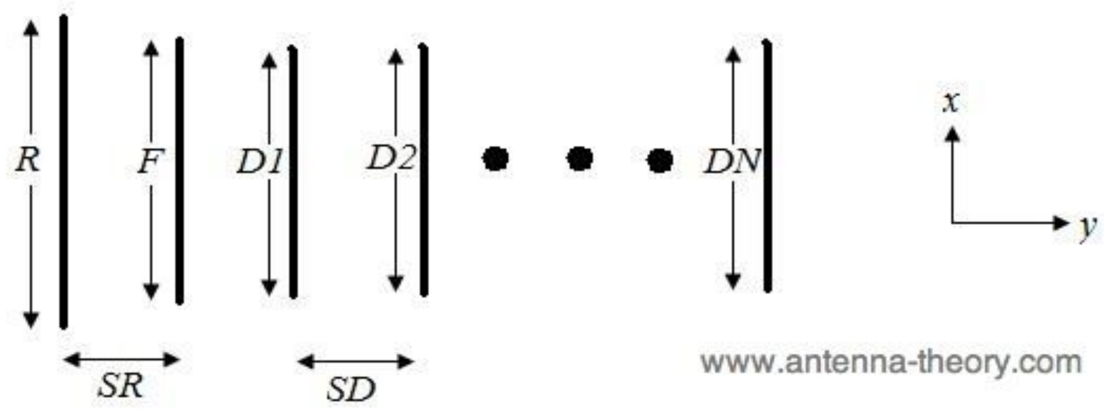
$$I_n(z') = \sum_{m=1}^{M} I_{nm} \cos\,[(2m-1)\pi z/l_n]$$

Where: *Inm represent the complex current coefficient of mode m on element n*

In represents the corresponding length on the n elements

Dependence of characteristic on design

- **Gain**: To Increase Gain
  - Adding Director help focus the radio waves in the desired direction
  - Increasing the size of the driven element
  - Element Spacing: Precisely adjusting to maximize gain
- But Increase gain will trade off **bandwidth**
- **Impedance**: multi element interact with each other influence Impedance
- Front to Back Ratio: Closer spacing will increase the directivity and gain, but it will also make the antenna more susceptible to interference..



Length and spacing design

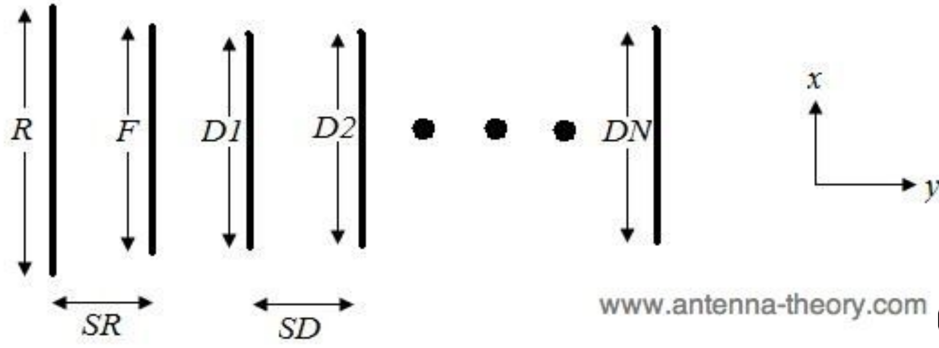
Design an Yagi-Uda antenna for a wanted Frequency:

- Calculate the wavelength **λ = c/f**
- **Driven length**: approximately half of wavelength **F ≈ λ/2**
- **Reflector length**: slightly longer (~5%) than the driven element **D ≈ 105%F**
- Reflector to driven element: **SR ≈ 0.15λ → 0.25λ**
- **Director length**: slightly Shorter (~5%) than the previous element
  - **D1 ≈ 95%F**
  - **DN ≈ 95%D(N-1)**
- Driven element to first director: **S ≈ 0.1λ → 0.2λ**
- Spacing between directors: **SD ≈ 0.15λ → 0.25λ**

Optimize as we go on to obtain the best characteristic:

Where:

+ c: Speed of light
+ f: Frequency
+ λ: Wave length
+ R: Reflector length
+ F: Driven length
+ D: Director length
+ SR: Spacing Reflector to driven
+ SD: Spacing between directors



Experimental data

Table I. Optimal Lengths for Yagi-Uda Elements, for Distinct Boom Lengths

d=0.0085 λ SR=0.2 λ	Boom Length of Yagi-Uda Array (in λ)					
	0.4	0.8	1.2	2.2	3.2	4.2
R	0.482	0.482	0.482	0.482	0.482	0.475
D1	0.442	0.428	0.428	0.432	0.428	0.424
D2		0.424	0.420	0.415	0.420	0.424
D3		0.428	0.420	0.407	0.407	0.420
D4			0.428	0.398	0.398	0.407
D5				0.390	0.394	0.403
D6				0.390	0.390	0.398
D7				0.390	0.386	0.394
D8				0.390	0.386	0.390
D9				0.398	0.386	0.390
D10				0.407	0.386	0.390
D11					0.386	0.390
D12					0.386	0.390
D13					0.386	0.390
D14					0.386	
D15					0.386	
Spacing between directors, (SD/ λ)	0.20	0.20	0.25	0.20	0.20	0.308
Gain (dB)	9.25	11.35	12.35	14.40	15.55	16.35

From *"Yagi Antenna Design" by P Viezbicke from the National Bureau of Standards, 1968*

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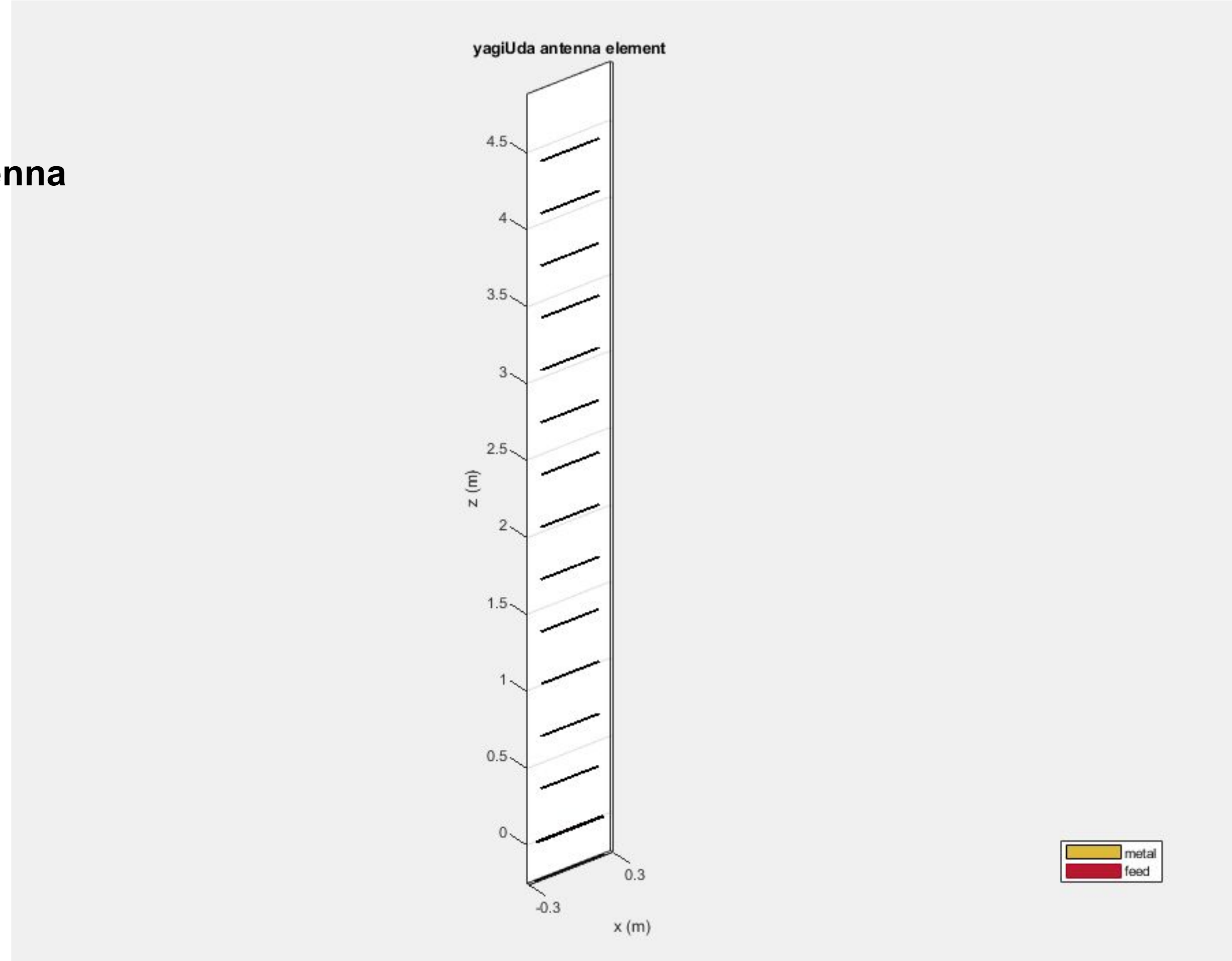
MATLAB Simulation

Create and View Yagi-Uda Array Antenna

y = yagiUda('NumDirectors',13);

show(y)

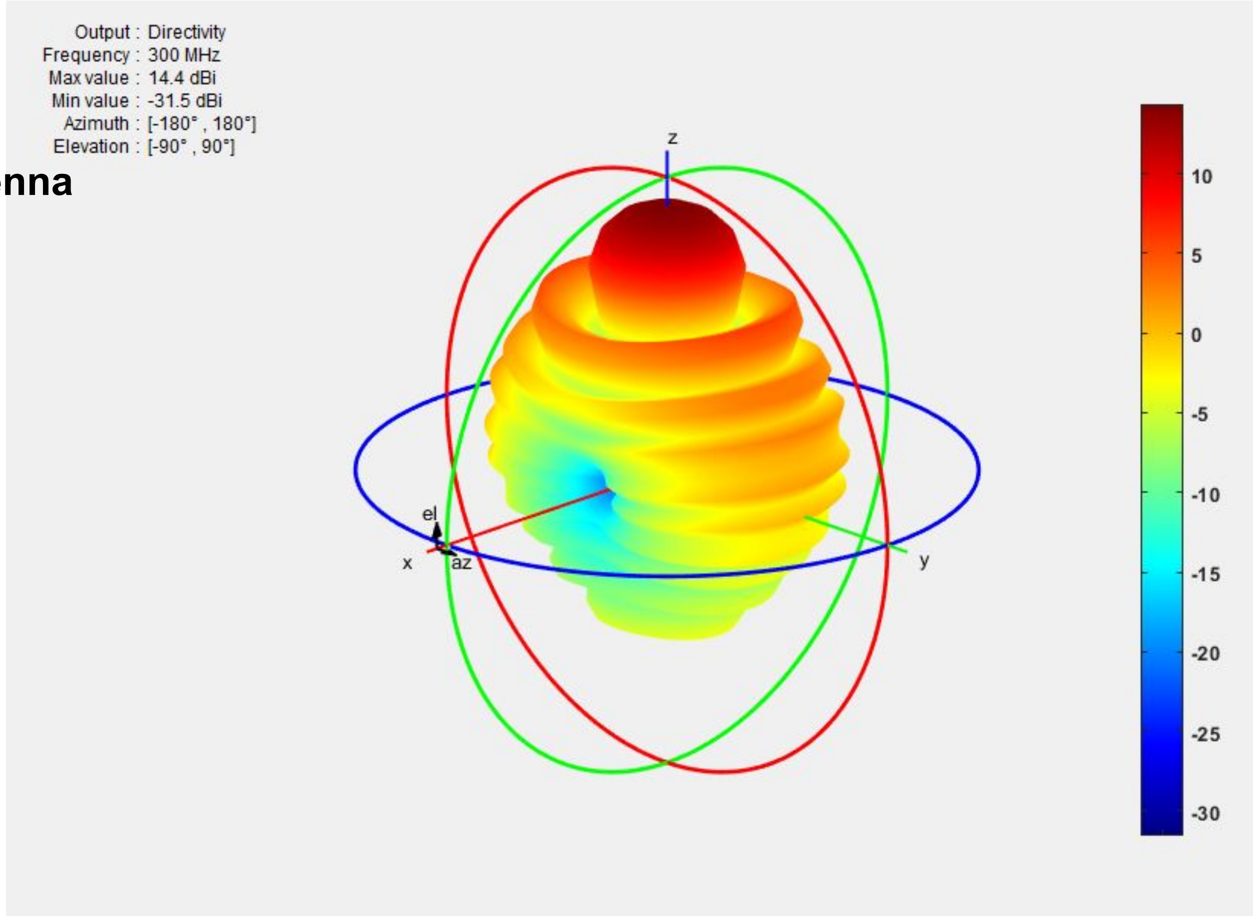


MATLAB Simulation

Radiation Pattern of Yagi-Uda Array Antenna

y = yagiUda('NumDirectors',13);

pattern(y,300e6)



MATLAB Simulation

Calculate Cylinder to Strip Approximation

```
>> w = cylinder2strip(20e-3)

w =

    0.0800
```

Advantages

- High gain is achieved.
- High directivity is achieved.
- Ease to manufacture and install.
- Ease of handling and maintenance.
- Less amount of power is wasted.
- Broader coverage of frequencies.
- Cost- effectiveness.

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Disadvantages

- Prone to noise.
- Prone to atmospheric effects.
- Can be somewhat large and unwieldy, especially at lower frequencies.

Applications

- Television and Radio: These antennas are commonly used for terrestrial television and radio broadcasting reception in suburban and rural areas where signal strength is relatively weak.
- Ham Radio: Due to its directional properties, the Yagi-Uda antenna is popular in amateur radio or ‘ham radio’ operations.

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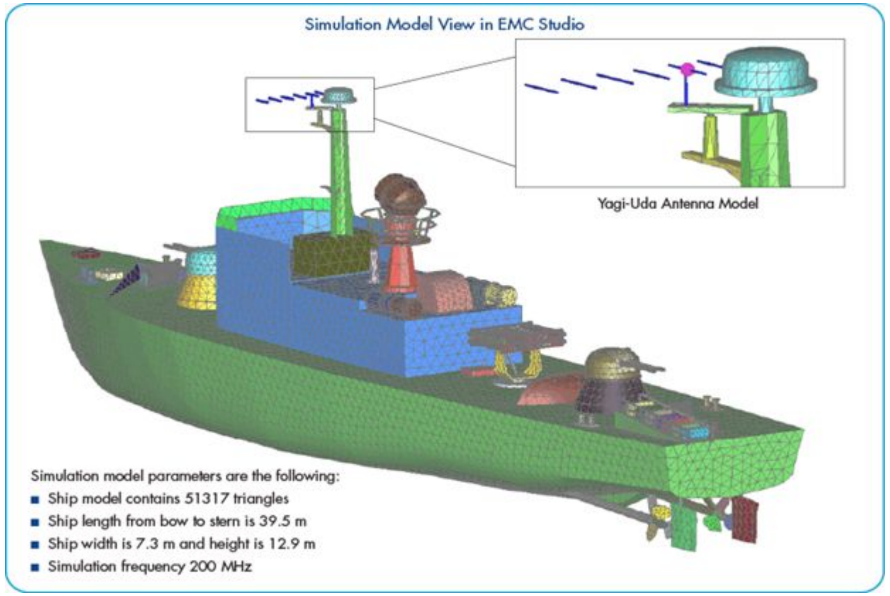
Applications

- Wireless Communication: Yagi-Uda antennas are also used in wireless communication systems, like WiFi and cellular networks, to provide focused coverage and minimize interference.
- Radar and Astronomy: They are utilized in radar systems for tracking and surveillance, as well as in radio astronomy for the study of celestial bodies.
- Used where a single-frequency application is needed.



Applications

The P18 radar

Large planar array antenna of a VHF Russian mobile air defense radar, the Nebo-M

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Conclusion

- A directional antenna invented by Yagi and Uda in 1926 Compose of 3 main part: Driven, Reflector, Director.
- Provide very high range but low bandwidth.
- There are no universal formula to calculate Yagi Uda antenna, method usually be use is simulation and experience.
- Its innovative structure and directional capabilities is useful in: communication systems, from amateur radio to modern wireless networks.
- The Yagi-Uda antenna continues to play a crucial role in shaping our connected world.

Thank you
for your listening