DTG3F3
Teknik Antena
dan propagasi

Antena Loop dan Helix

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Varian Antena Dipole dan Monopole

Materi di sadur dari buku
"ANTENNAS"
Oleh John D. Kraus
Dan
"ANTENNAS
FROM THEORY TO PRACTICE"
Oleh Yi Huang dan Kevin Boyle
Dan
"ANTENNA THEORY
ANALYSIS AND DESIGN"
oleh Constantine A. Balanis

Loop Antenna

- A loop antenna is a antenna consisting of a loop (or loops) of wire, tubing, or other electrical conductor with its ends connected to a balance or unbalance transmission line
- Loop antennas take many different configu-rations, which include circular, square, rectangular, triangular, elliptical and other shapes

Klasifikasi antena Loop

Loop antennas are usually classified into two categories:

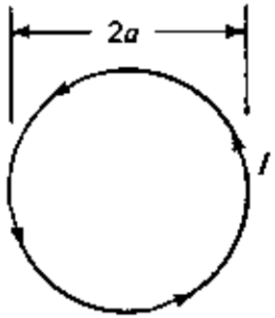
1. electrically small Loop ($C < \lambda/10$)
2. electrically large loops ($C \sim \lambda$) → Resonant Loop

Aplikasi antena Loop

Most of the applications of loop antennas are in the HF (3 – 30 MHz), VHF (30 – 300 MHz), and UHF (300 – 3,000 MHz) bands

Electrically small Loop

Karakteristik



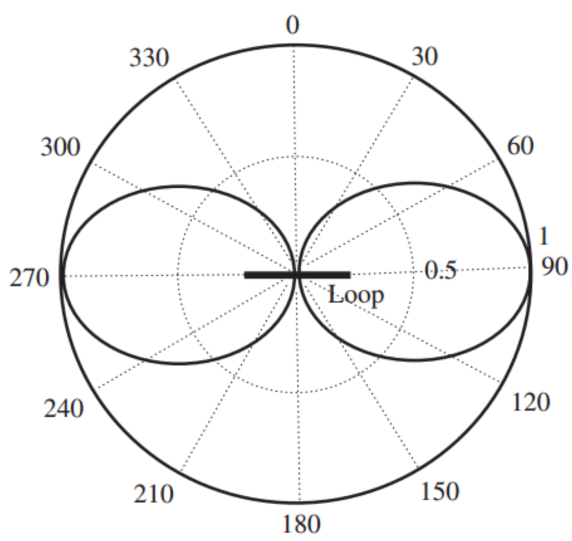
circumference
C = 2πa < λ/10

- Electrically small loop have small radiation resistances that are usually smaller than their loss resistances. Thus they have poor efficiency and they are very poor radiators.
- Antena ini jarang digunakan pada mode transmit pada komunikasi radio, kalaupun digunakan biasanya pada mode receive, seperti pada portable radio dan pager, dimana parameter S/N lebih penting daripada efisiensi antena.
- Selain itu antena ini juga sering digunakan sebagai probe dalam pengukuran medan elektromagnetik, dan digunakan pada radiowave navigation.

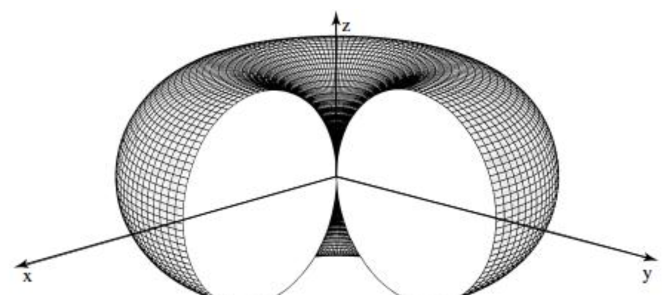
Electrically small Loop

Karakteristik

- The field pattern of electrically small antennas of any shape (circular, elliptical, rectangular, square, etc.) is similar to that of an infinitesimal dipole with <u>a null perpendicular to the plane of the loop and with its maximum along the plane of the loop (θ = π/2)</u>



The radiation pattern looks the same as a short dipole, but the polarization is now Eφ (not Eθ, but still <u>linearly polarized</u>)

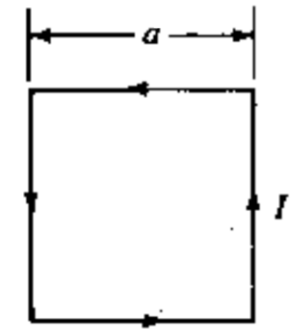


(a) $C = 0.1\lambda$

Electrically small Loop

Karakteristik

Parameter	Formula
	Small Circular Loop $(a < \lambda/6\pi, C < \lambda/3)$ **(Uniform Current)**
Normalized power pattern	$U = \lvert E_{\phi n}\rvert^2 = C_0 \sin^2\theta$
Wave impedance Z_w	$Z_w = -\frac{E_\phi}{H_\theta} \simeq \eta = 377 \text{ Ohms}$
Directivity D_0	$D_0 = \frac{3}{2} = 1.761 \text{ dB}$
Maximum effective area A_{em}	$A_{em} = \frac{3\lambda^2}{8\pi}$
Radiation resistance R_r (one turn)	$R_r = 20\pi^2\left(\frac{C}{\lambda}\right)^4$
Radiation resistance R_r (N turns)	$R_r = 20\pi^2\left(\frac{C}{\lambda}\right)^4 N^2$
Input resistance R_{in}	$R_{in} = R_r = 20\pi^2\left(\frac{C}{\lambda}\right)^4$
Loss resistance R_L (one turn)	$R_L = \frac{l}{P}\sqrt{\frac{\omega\mu_0}{2\sigma}} = \frac{C}{2\pi b}\sqrt{\frac{\omega\mu_0}{2\sigma}}$
Loss resistance R_L (N turns)	$R_L = \frac{Na}{b}R_s\left(\frac{R_p}{R_0}+1\right)$
Loop external inductance L_A	$L_A = \mu_0 a\left[\ln\left(\frac{8a}{b}\right) - 2\right]$
Loop internal inductance L_i	$L_i = \frac{a}{\omega b}\sqrt{\frac{\omega\mu_0}{2\sigma}}$
Vector effective length $\boldsymbol{\ell}_e$	$\boldsymbol{\ell}_e = \hat{\mathbf{a}}_\phi jk_0\pi a^2\cos\psi_i\sin\theta_i$
Half-power beamwidth	$\text{HPBW} = 90°$

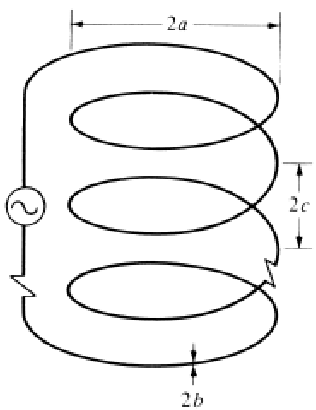


	Small Square Loop **(Figure 5.17)** **(Uniform Current, a on Each Side**
Normalized power pattern (principal plane)	$U = \lvert E_{\phi n}\rvert^2 = C_2\sin^2\theta$
Wave impedance Z_w	$Z_w = -\frac{E_\phi}{H_\theta} \simeq \eta = 377 \text{ Ohms}$
Radiation resistance R_r	$R_r = 20\left(\frac{2\pi a}{\lambda}\right)^4 = 20\left(\frac{C}{\lambda}\right)^4$
Input resistance R_{in}	$R_{in} = R_r = 20\left(\frac{4a}{\lambda}\right)^4 = 20\left(\frac{P}{\lambda}\right)^4$
Loss resistance R_L	$R_L = \frac{4a}{P}\sqrt{\frac{\omega\mu_0}{2\sigma}} = \frac{4a}{2\pi b}\sqrt{\frac{\omega\mu_0}{2\sigma}}$
External inductance L_A	$L_A = 2\mu_0\frac{a}{\pi}\left[\ln\left(\frac{a}{b}\right) - 0.774\right]$
Internal inductance L_i	$L_i = \frac{4a}{\omega P}\sqrt{\frac{\omega\mu_0}{2\sigma}} = \frac{4a}{2\pi b\omega}\sqrt{\frac{\omega\mu_0}{2\sigma}}$

Electrically small Loop

Untuk meningkatkan efisiensi small Loop

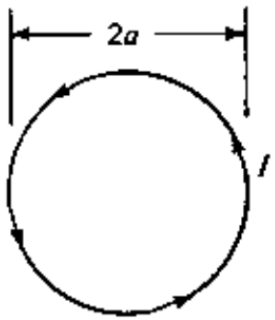
- The radiation resistance of the loop can be increased, and made comparable to the characteristic impedance of practical transmission lines, by :
  a) increasing (electrically) its perimeter
  b) increasing the number of turns
  c) insert, within its circumference or perimeter, a ferrite core of very high permeability which will raise the magnetic field intensity and hence the radiation resistance. This forms the so called **ferrite loop**.



(a) *N*-turn circular loop

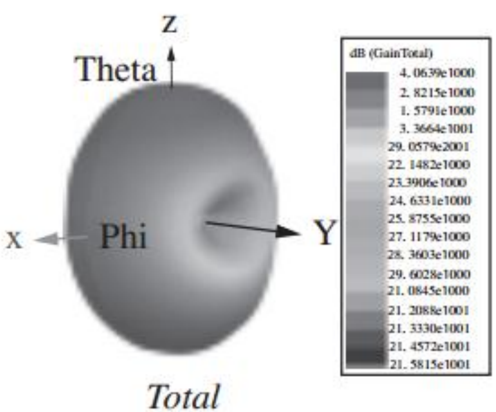
Electrically Large Loop

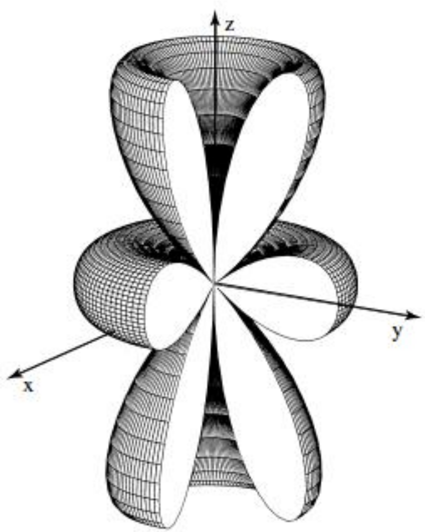
Karakteristik



circumference
C = 2πa ≈λ)

- As the overall length of the loop increases and its cir-cumference approaches one free space wavelength, the maximum of the pattern shifts <u>from the plane of the loop to the axis of the loop which is perpendicular to its plane (θ = 0 and π)</u>.
- The multiple lobes in a large loop begin to form when the circumference exceeds about 3.83λ (radius exceeds about 0.61λ)



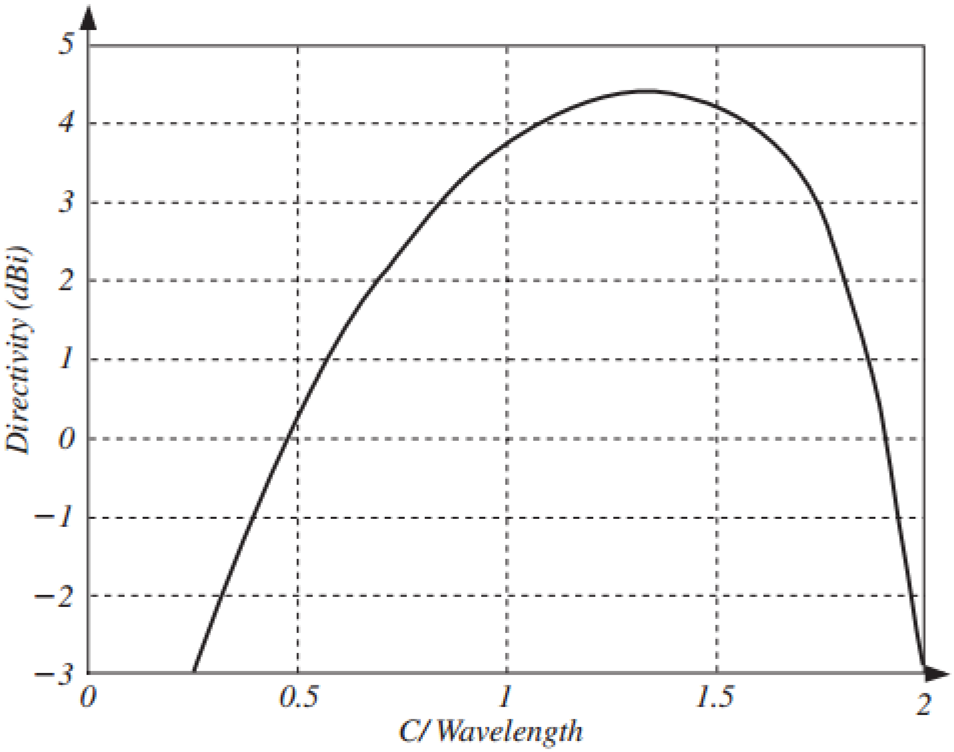


(b) $C = 5\lambda$

Electrically Large Loop

Karakteristik

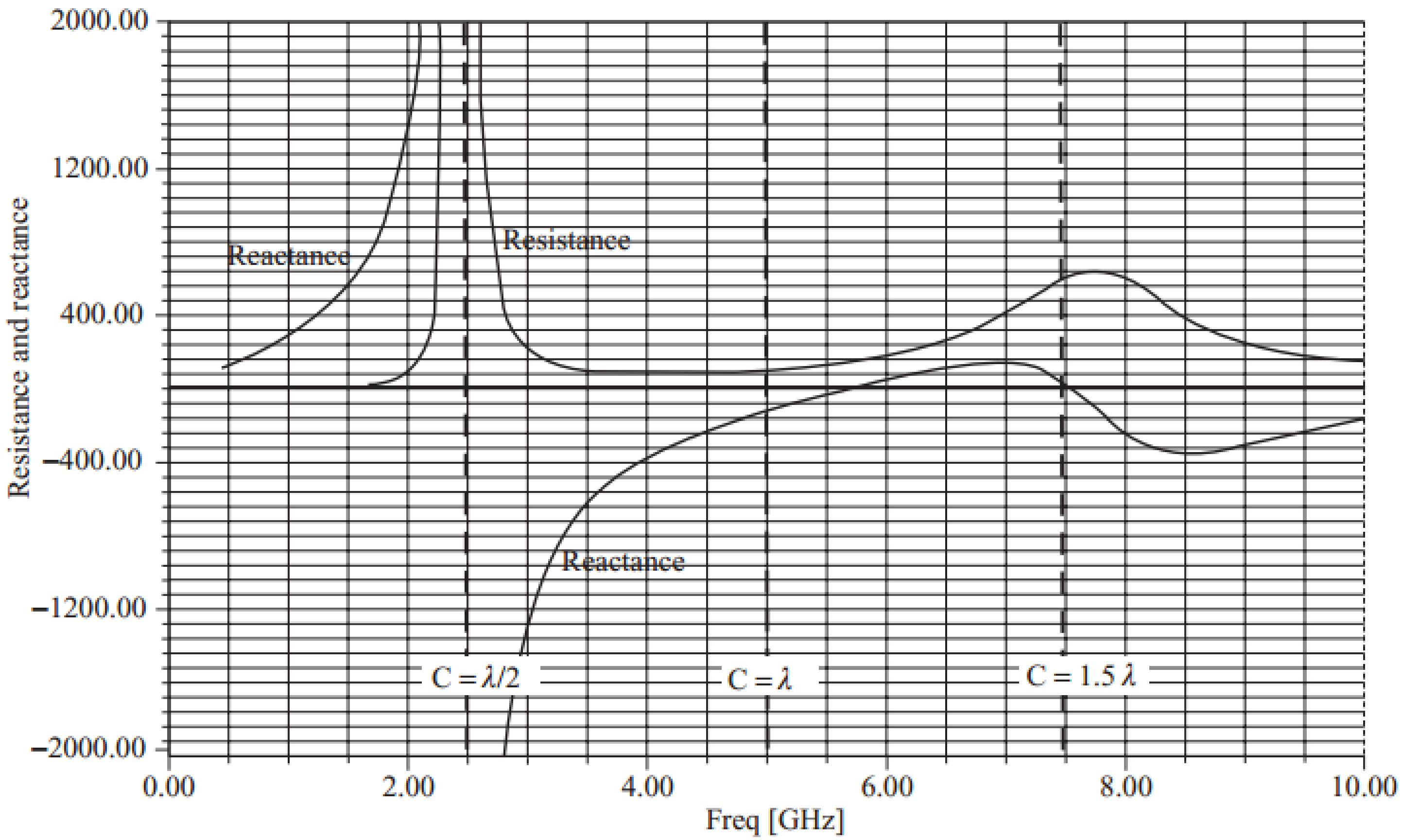
- Karakteristik Directivity



Electrically large Loop

Karakteristik

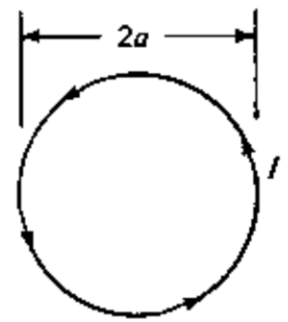
- Karakteristik Impedansi→ freq 5Ghz, C = 6 cm



Electrically Large Loop

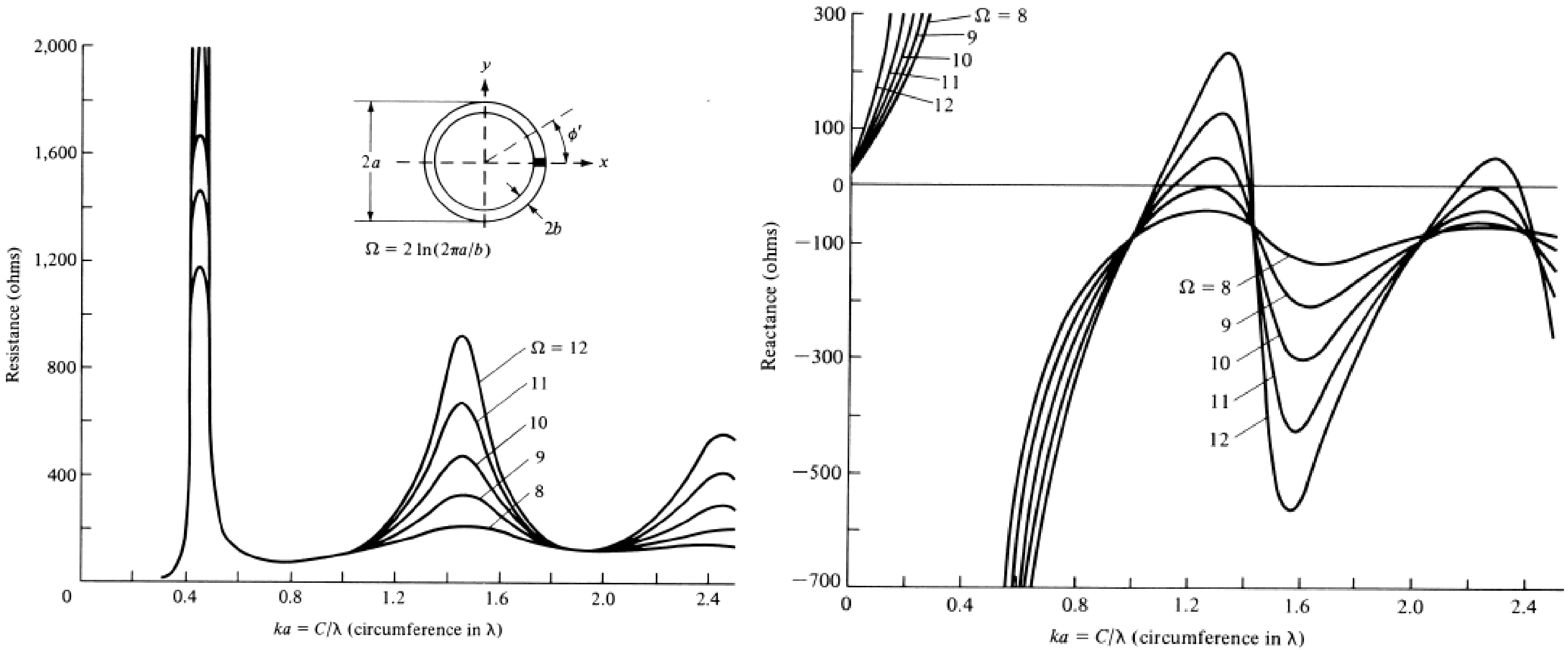
Karakteristik

	Large Circular Loop ($a \geq \lambda/2$, $C \geq 3.14\lambda$) (Uniform Current)	
Normalized power pattern	$U = \|E_{\phi n}\|^2 = C_1 J_1^2(ka \sin\theta)$	(5-57)
Wave impedance Z_w	$Z_w = -\frac{E_\phi}{H_\theta} \simeq \eta = 377 \text{ Ohms}$	(5-28)
Directivity D_0 ($a > \lambda/2$)	$D_0 = 0.677\left(\frac{C}{\lambda}\right)$	(5-63b)
Maximum effective area A_{em} ($a > \lambda/2$)	$A_{em} = \frac{\lambda^2}{4\pi}\left[0.677\left(\frac{C}{\lambda}\right)\right]$	(5-63c)
Radiation resistance ($a > \lambda/2$), (one turn)	$R_r = 60\pi^2\left(\frac{C}{\lambda}\right)$	(5-63a)
Input resistance ($a > \lambda/2$), (one turn)	$R_{in} = R_r = 60\pi^2\left(\frac{C}{\lambda}\right)$	(5-63a)
Loss resistance R_L (one turn)	$R_L = \frac{l}{P}\sqrt{\frac{\omega\mu_0}{2\sigma}} = \frac{C}{2\pi b}\sqrt{\frac{\omega\mu_0}{2\sigma}}$	(2-90b)
Loss resistance R_L (N turns)	$R_L = \frac{Na}{b}R_s\left(\frac{R_p}{R_0}+1\right)$	(5-25)
External inductance L_A	$L_A = \mu_0 a\left[\ln\left(\frac{8a}{b}\right)-2\right]$	(5-37a)
Internal inductance L_i	$L_i = \frac{a}{\omega b}\sqrt{\frac{\omega\mu_0}{2\sigma}}$	(5-38)
Vector effective length $\boldsymbol{\ell}_e$	$\boldsymbol{\ell}_e = \hat{\mathbf{a}}_\phi\, jk_0\pi a^2 \cos\psi_i \sin\theta_i$	(5-40)



C = circumference

Design Procedure



(a) Resistance

(b) Reactance

To resonate the loop, usually a capacitor in parallel or an inductor in series is added, depending on the radius of the loop and that of the wire

Pengembangan Antena Loop

(b) array of eight elements

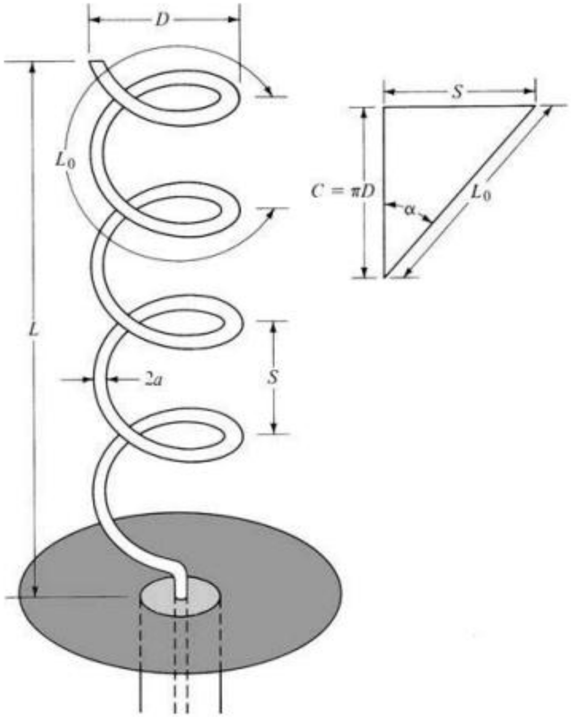


Figure 10.13 Helical antenna with ground plane.

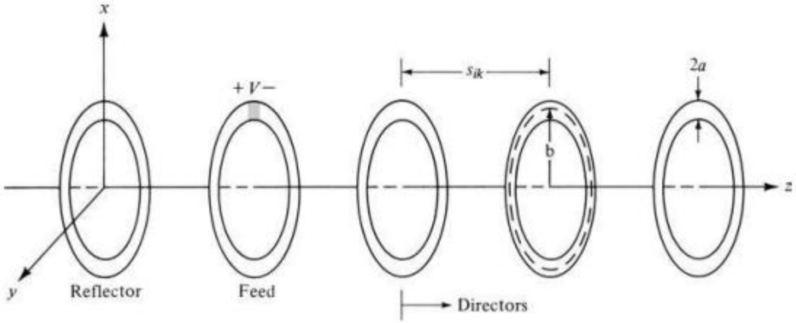


Figure 10.30 Yagi-Uda array of circular loops.

Antena Helix

- **Mode radiasi pada helix ada 2 macam :**

Operational Modes

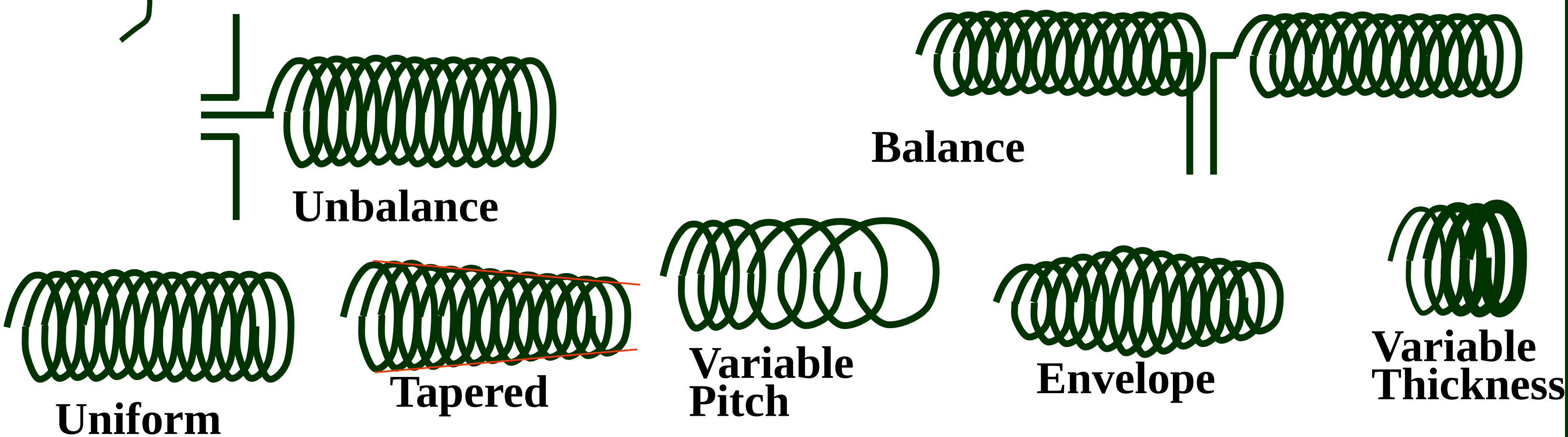
- **Normal Mode Radiation**

$$C_\lambda < \frac{1}{3}$$

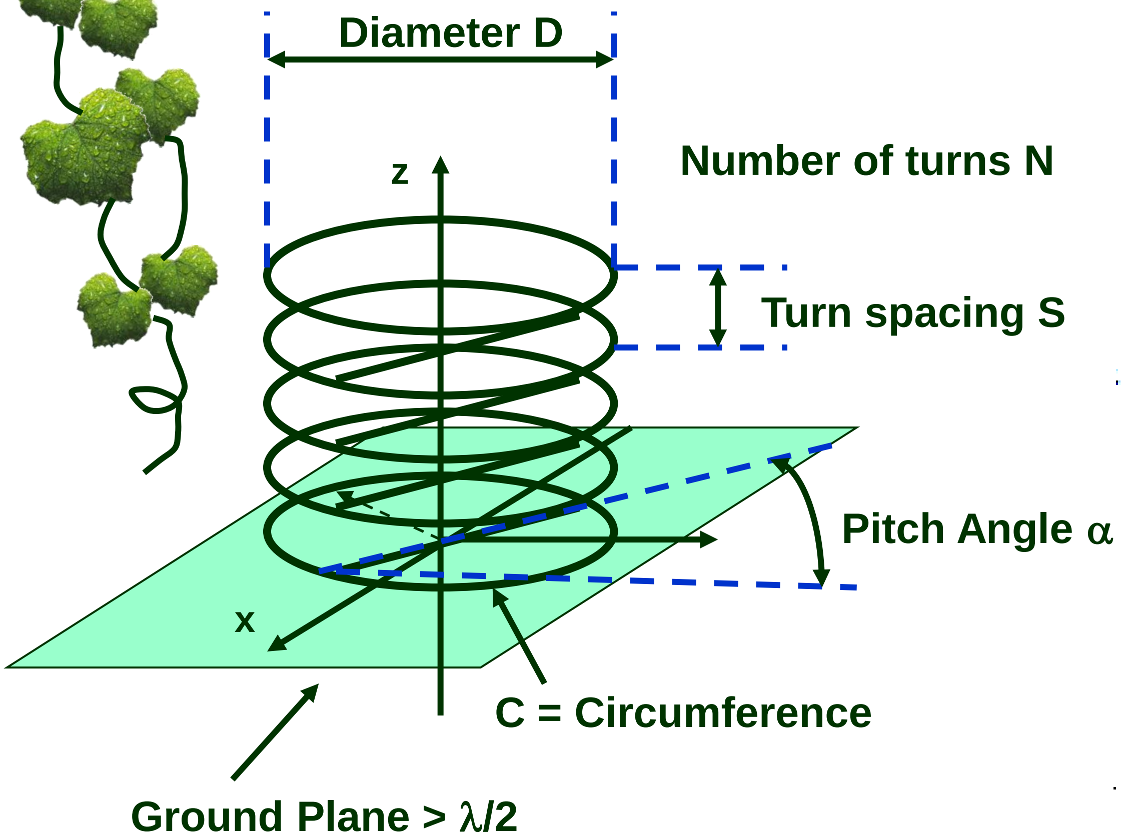
- **Axial Mode Radiation**

$$\frac{3}{4} < C_\lambda < \frac{4}{3}$$

- **Macam-Macam antena helix :**



- **Dimensi-Dimensi pada helix :**



$C = \pi . D$ = kelililing lingkaran

S = Spasi / pitch

N = Jumlah lilitan

$L = NS$ = Panjang helix (sumbu helix)

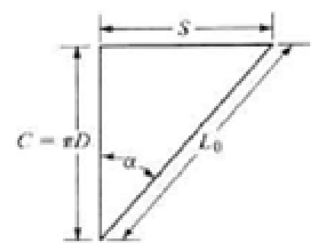
$L_D = \sqrt{S^2 + C^2}$

= Panjang satu lilitan

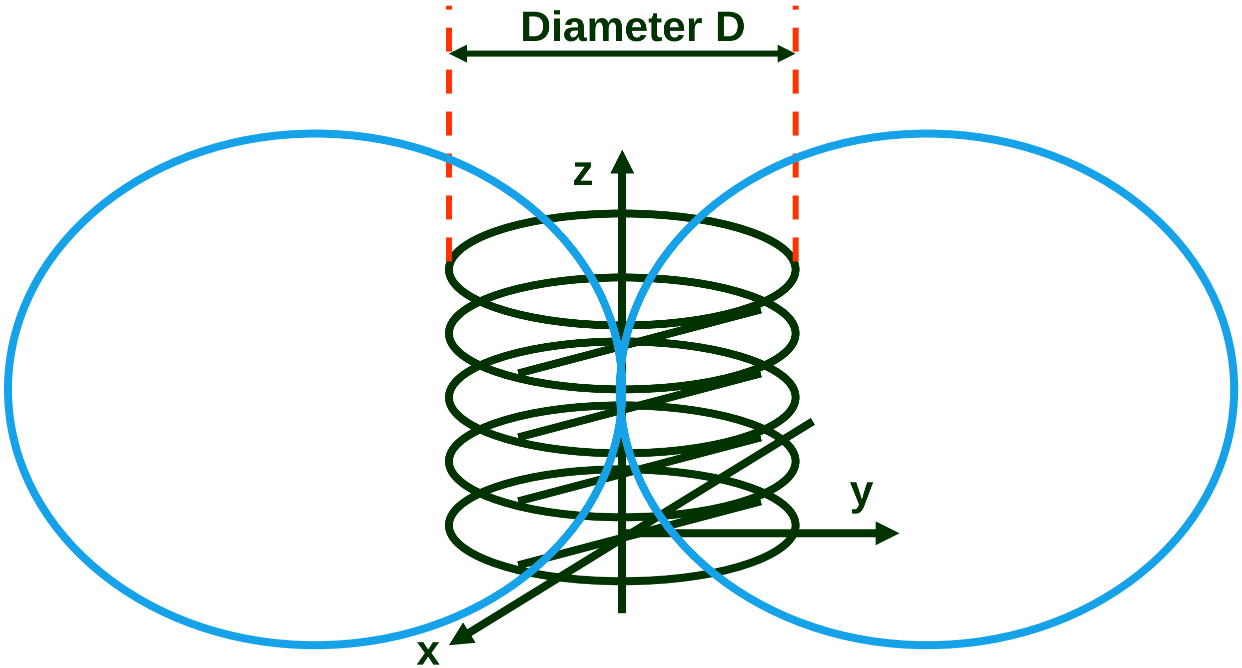
$L_N = NL_D$ = panjang kawat

α = Pitch angle = $\tan^{-1}\left(S/C\right)$

$C_\lambda = \pi D / \lambda$



- **Normal Mode Radiation**



Normal Mode Radiation (broadside) terjadi jika :

$D \ll \lambda$ atau , $L_N \ll \lambda$

- **Distribusi Medan Mode Normal**

$$E_{\theta} = j\frac{60\pi[I]\sin\theta}{r}\frac{S}{\lambda}$$

$$E_{\phi} = \frac{120\pi^2[I]\sin\theta}{r}\frac{A}{\lambda^2}$$

dengan,

$$A = \frac{\pi D^2}{4}$$

Polarisasi Eliptis

$$AR = \textbf{\textit{Axial Ratio}} = \frac{|E_{\theta}|}{|E_{\phi}|} = \frac{S_{\lambda}}{2\pi A} = \frac{2S_{\lambda}}{C_{\lambda}^{2}}$$

Polarisasi Sirkular

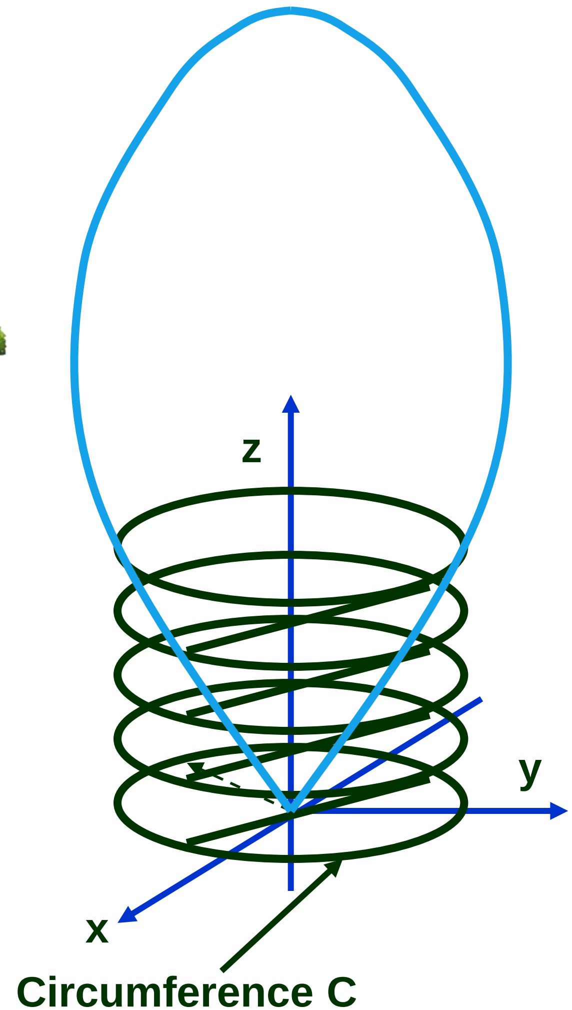
$$AR = 1$$

$$C_{\lambda} = \sqrt{2S_{\lambda}} = \frac{\pi D}{\lambda}$$

$$\tan\alpha = \frac{C_{\lambda}}{2} = \frac{\pi D}{2\lambda}$$

Antena Helix

- **Axial Mode Radiation** preferred mode



Axial Mode Radiation (endfire) terjadi jika :

$$3/4 < C_\lambda < 4/3$$

Sifat-sifat mode axial

1. **Narrow Mainbeam dengan minor sidelobes**
2. **Polarisasi sirkular (orientation ~ helix orientation)**
3. **Bandwidth lebar dibandingkan mode normal**
4. **Tanpa kopling antar elemen**
5. **Dapat disusun dengan helix lainnya untuk meningkatkan gain**
6. **Perancangan tidak kritis**

- **Parameter** of Axial Mode Radiation

$$E = \sin\left(\frac{\pi/2}{N}\right)\frac{\sin\left(N\,\psi/2\right)}{\sin\left(\psi/2\right)}\cos\phi$$

dengan

$$\psi = 2\pi\left[S_\lambda(1-\cos\phi) + \frac{1}{2N}\right]$$

$$HPBW = \frac{52^o}{\left(C_\lambda\sqrt{NS_\lambda}\right)}$$

$$FNBW = \frac{115^o}{\left(C_\lambda\sqrt{NS_\lambda}\right)}$$

$$D = 12\,C_\lambda{}^2 S_\lambda N$$

$$R_T = 140\,C_\lambda$$

$$AR = \frac{2N+1}{2N}$$

Antena Helix

Contoh Perancangan

Rancanglah antena helix dengan 5 lilitan yang memiliki spesifikasi sebagai berikut :

- Frekuensi kerja : 400 Mhz
- Pola radiasi : broadside
- Polarisasi : circular
- Spasi perputaran : $\lambda/50$

Tentukan :

a) Keliling dari helix
b) Panjang kawat yang diperlukan
c) Panjang helix
d) Pitch angle

Questions???

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Thank You !