Waves and Antenna (1) (E1411)

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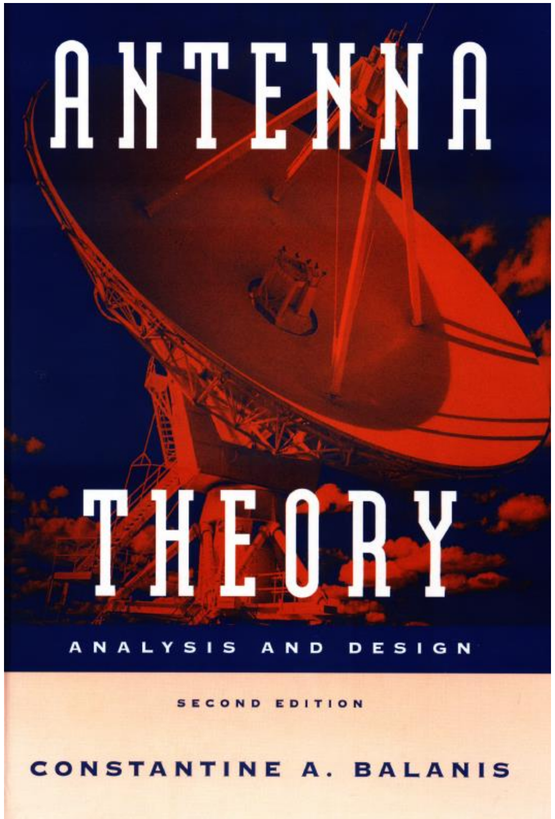
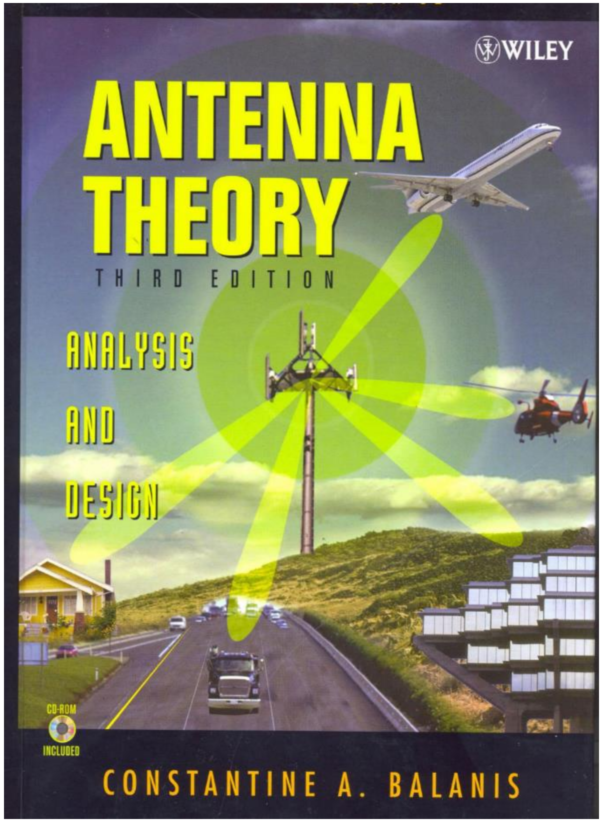
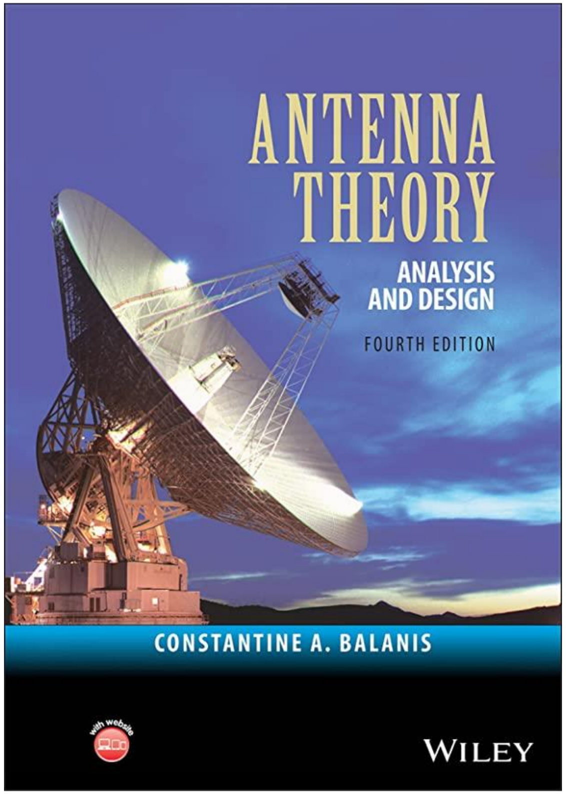
- Course code (Waves and Antenna (1) (E1411)

Textbook

Antenna Theory: Analysis and Design
Author: Constantine A. Balanis







If all accelerating electric charges radiate, then the wires that connect my computer to the wall should be antennas, correct?

Answer is **yes**. However, they are very poor antennas as the radiation is cancelled over two wires carrying current in the opposite directions.

If it is so simple, then everything could be an antenna. Why don't we just use a metal paper clip as an antenna, hook it up to the receiver ?

Answer: A paper clip could act as an antenna for some given conditions. The impedance controls how much power the receiver or transmitter could deliver to the paper clip. Impedance depends on the operating frequency.

Chapter 1

Antennas

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Chapter 1
Antennas

1.1 Introduction

1.2 Types of Antennas

What is antenna?

Definition :

"a means for radiating or receiving radio waves."

Transitional structure between free-space and a guiding device

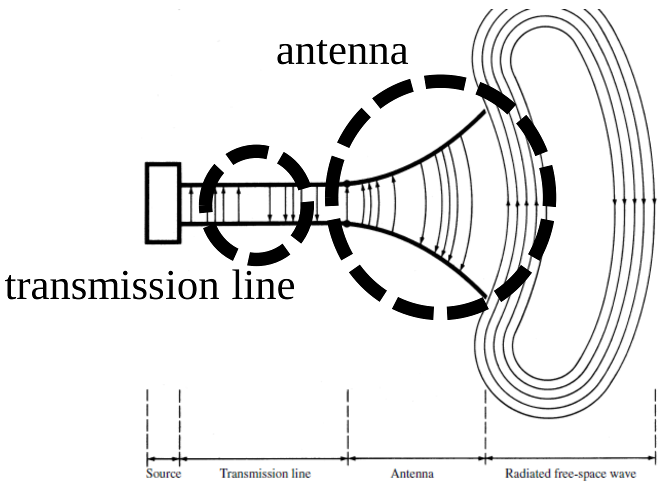


Figure 1.1 Antenna as a transition device.

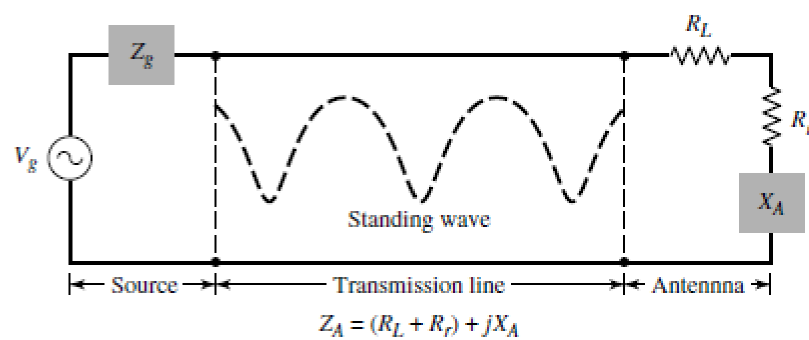
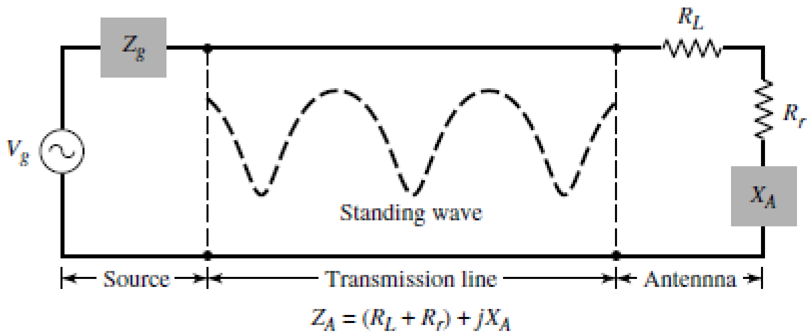


Figure 1.2 Transmission-line Thevenin equivalent of antenna in transmitting mode.



$$Z_A = (R_L + R_r) + jX_A$$

R_r → radiation

R_L → conduction,dielectric losses

Figure 1.2 Transmission-line Thevenin equivalent of antenna in transmitting mode.

Maximum power is delivered to the antenna under *conjugate matching.*

$$R_r + R_L = R_g \;,\; X_A = -X_g$$

What are not antennas?

compass
only receiving magnetic field

What about human eyes?

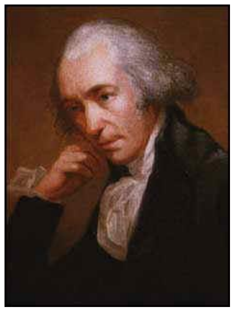
The human eye of course receives high frequency electromagnetic waves but cannot transmit waves.

Therefore, eyes are not the antenna.

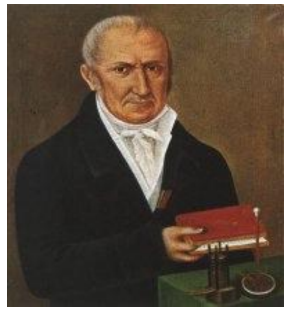
LIST OF HONOUR

Charles de Coulomb
1736-1806

James Watte
1736-1819



Alessandro Volta
1745-1827

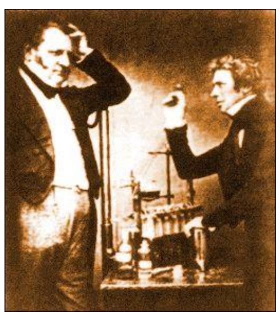


André Marie Ampère
1775- 1836

Carl Friedrich Gauss
1777-1855

Simeon Denis Poisson
1781-1840

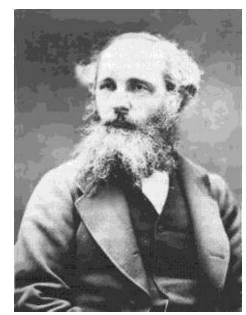
Georg Simon Ohm
1787-1854



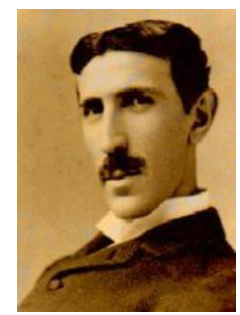
Michael Faraday
1791-1867

James Prescott Joule
1818-1889

Hermann von Helmholtz
1821-1894



James Clerk Maxwell
1834-1879



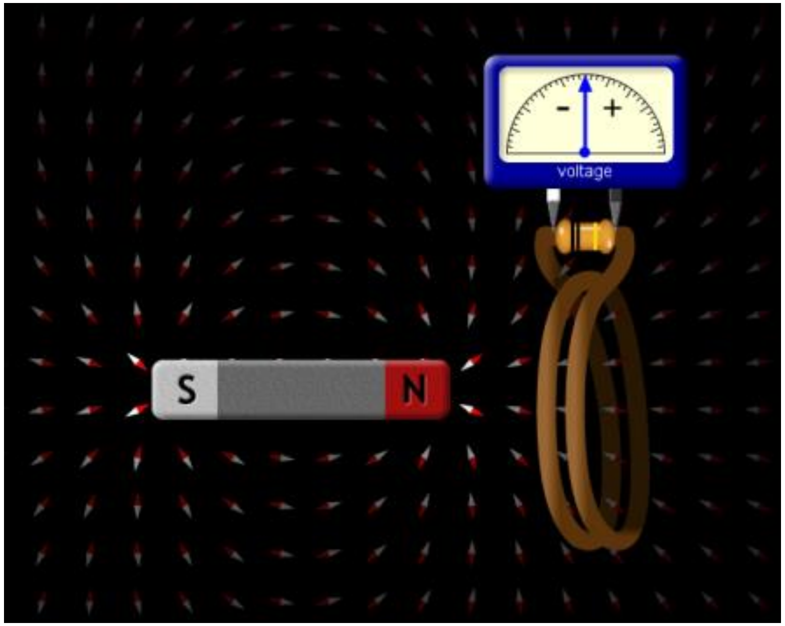
Nikola Tesla
1865-1943

Coupling of electricity and magnetism

Michael Faraday
1791-1867

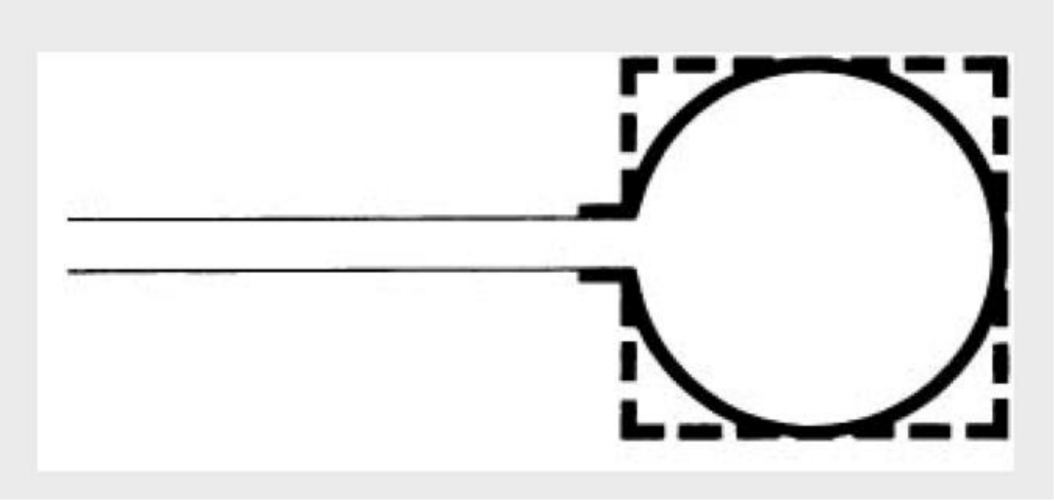
He slid a magnetic around the coils of a wire attached to a galvanometer.

In moving the magnet, he was creating a time-varying magnetic field, which as a result (from Maxwell's Equations), must have had a time-varying electric field.



The coil acts as a loop antenna.

It receives the EM radiation which is detected by the ampere meter.

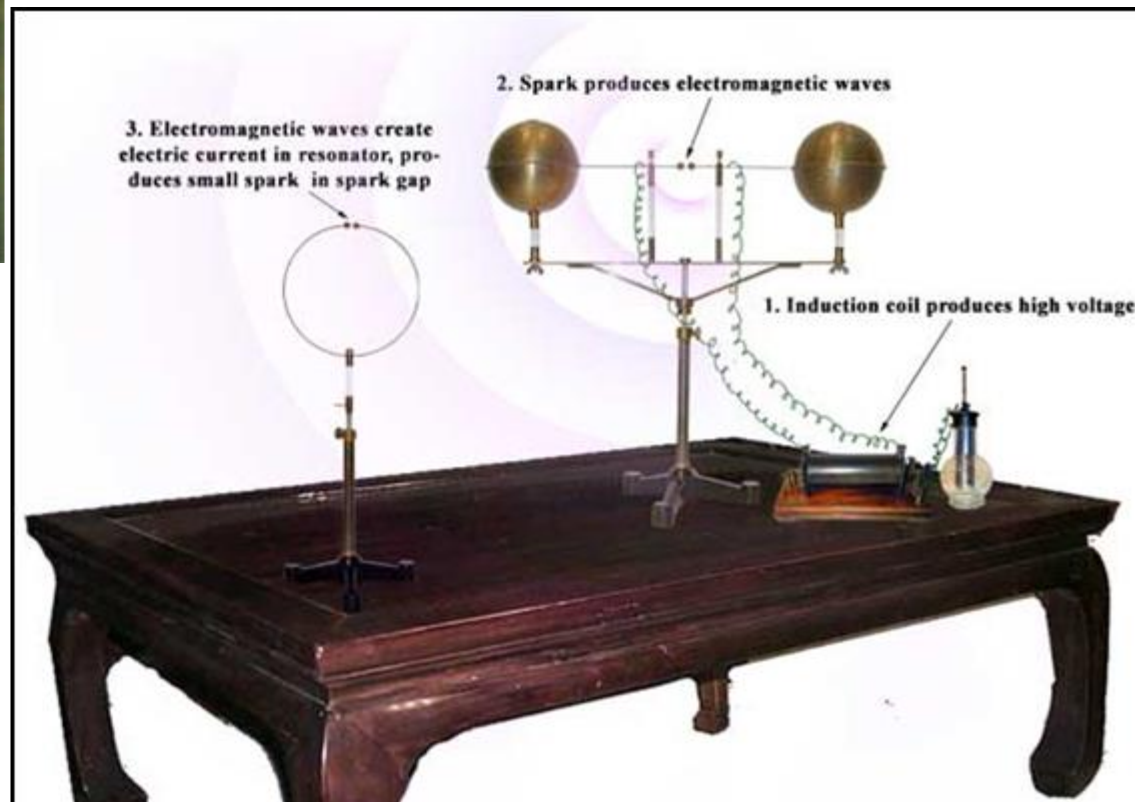


Hertz’s wireless communication system

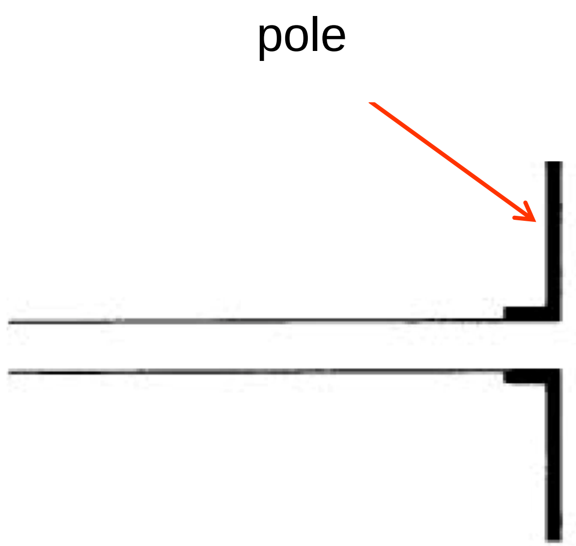
Heinrich Hertz
1857-1894

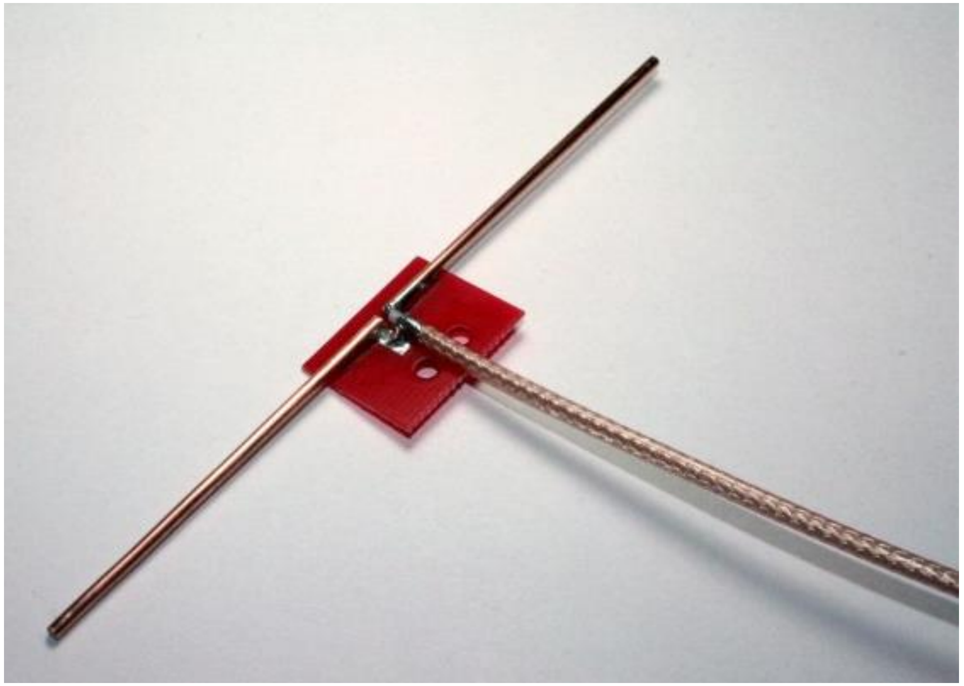
He observed an electrical spark in the gap of a dipole antenna.

When using a loop antenna as a receiver, he observed a similar disturbance.

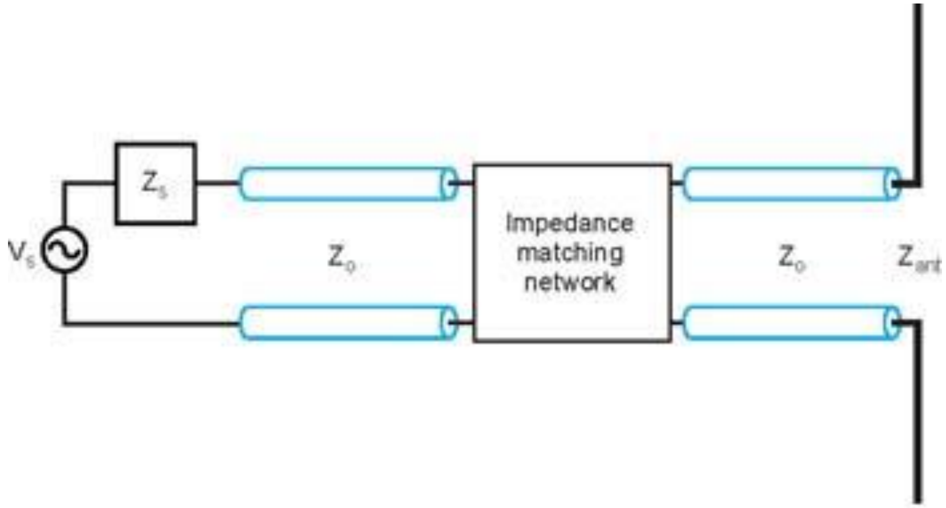


Dipole antenna





Generic Antenna network



- Complex antenna impedance Z_{ant} needs to be matched to the system impedance.

Types Of Antennas

1. Wire antennas
2. Aperture antennas
3. Microstrip antennas
4. Array antennas
5. Reflector antennas
6. Lens antennas

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Wire Antennas

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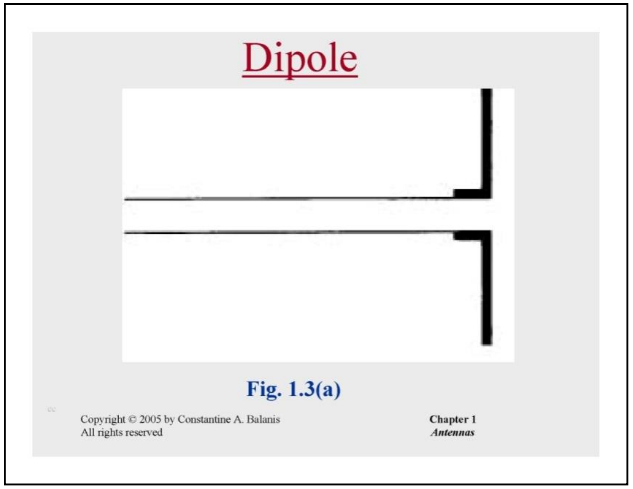
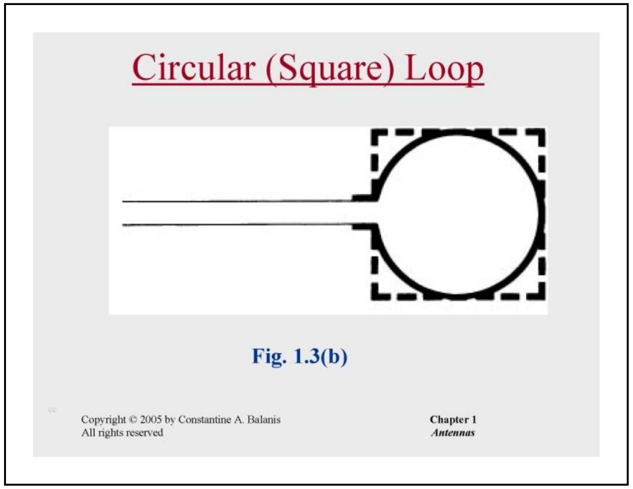
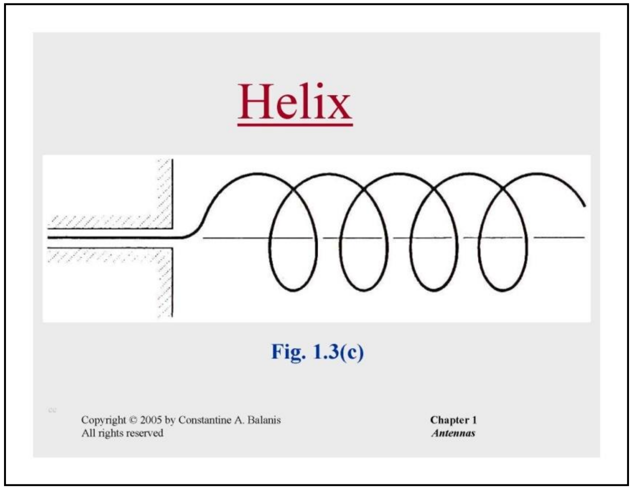
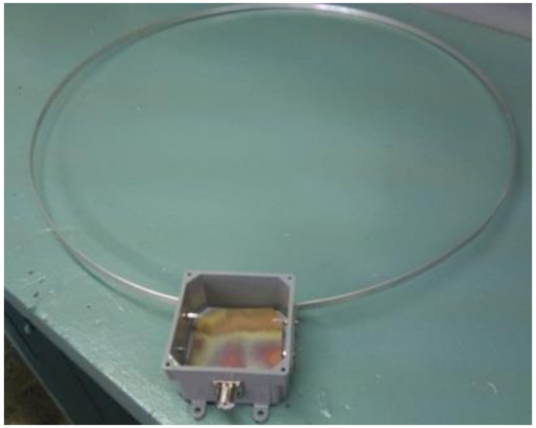
Wire antennas









Aperture Antennas

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Aperture antennas

- Horn antennas have a directional radiation pattern with a high antenna gain, 10-20 dB is typical.
- Horn antennas are also often used to feed a dish antenna, or as a "standard gain" antenna in measurements.
- The popular design is pyramidal horn.

Rectangular Waveguide

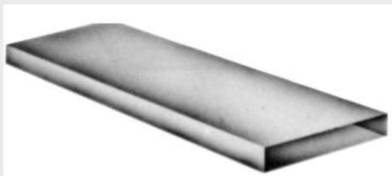

Fig. 1.4(c)

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Conical Horn

Fig. 1.4(b)

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Pyramidal Horn

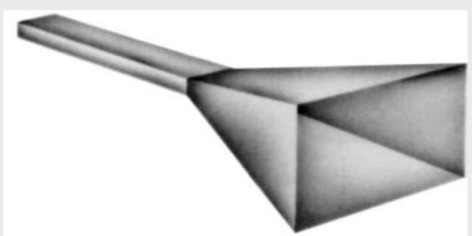

Fig. 1.4(a)

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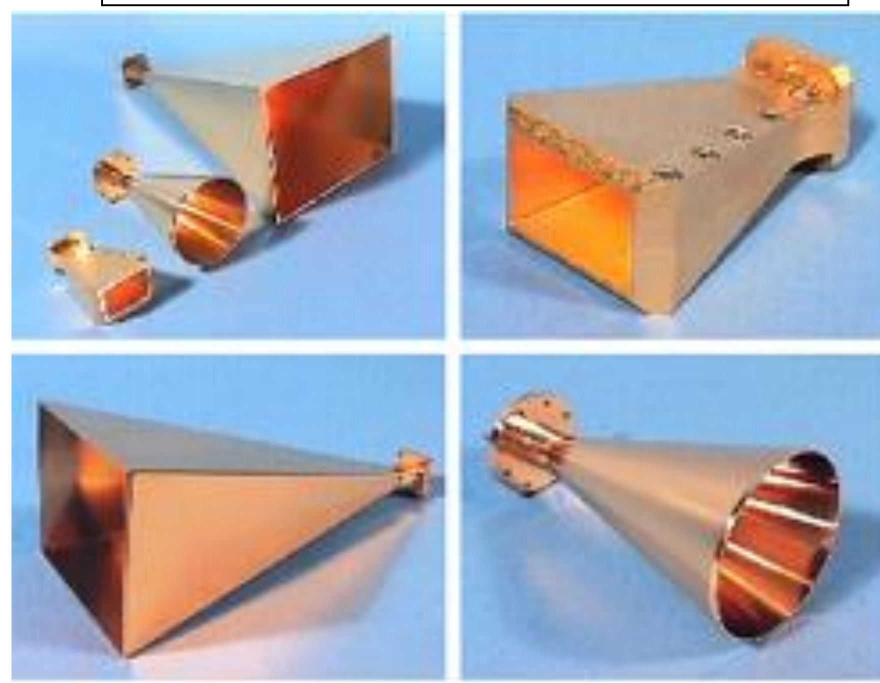

Microstrip Antennas

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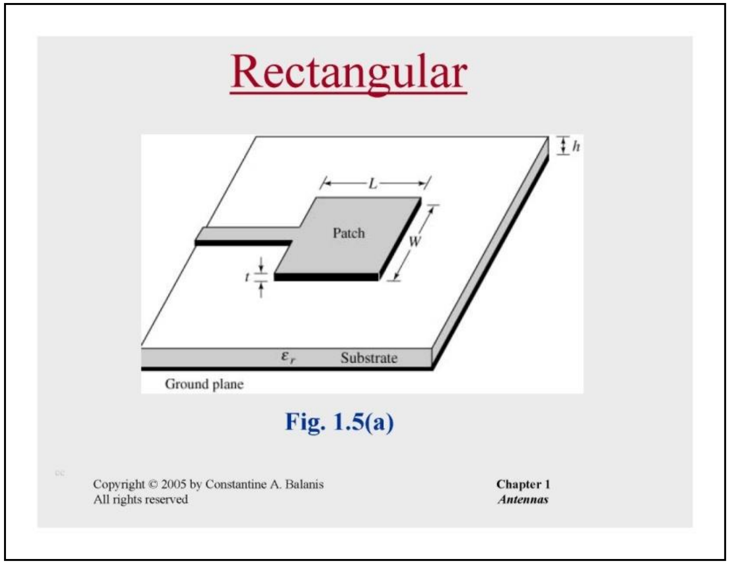
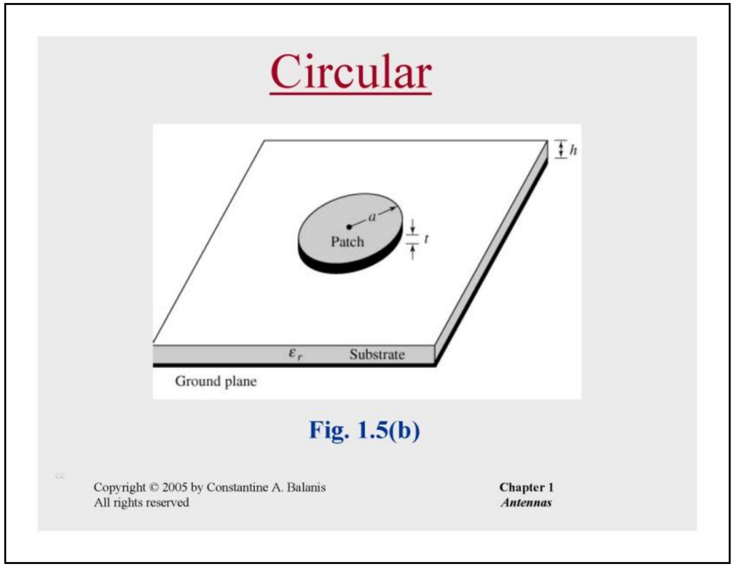
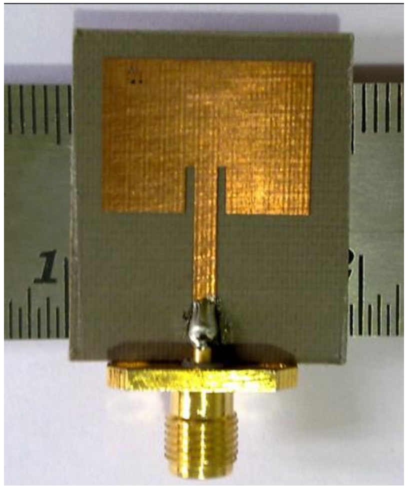
Microstrip or patch antennas







Array Antennas

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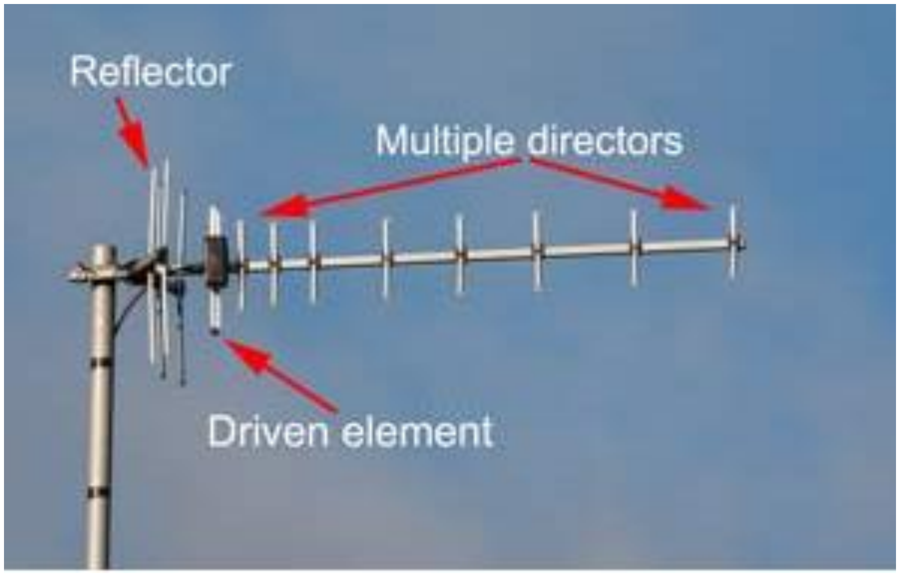
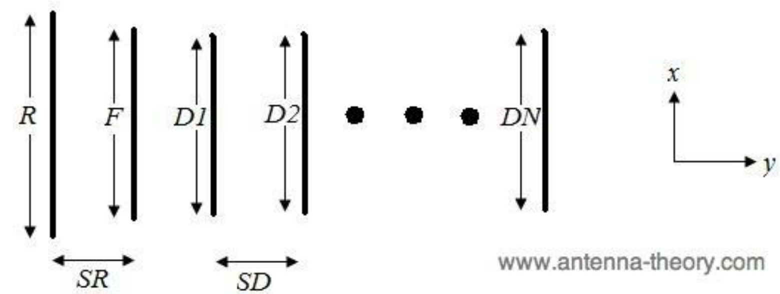
Yagi-Uda antenna



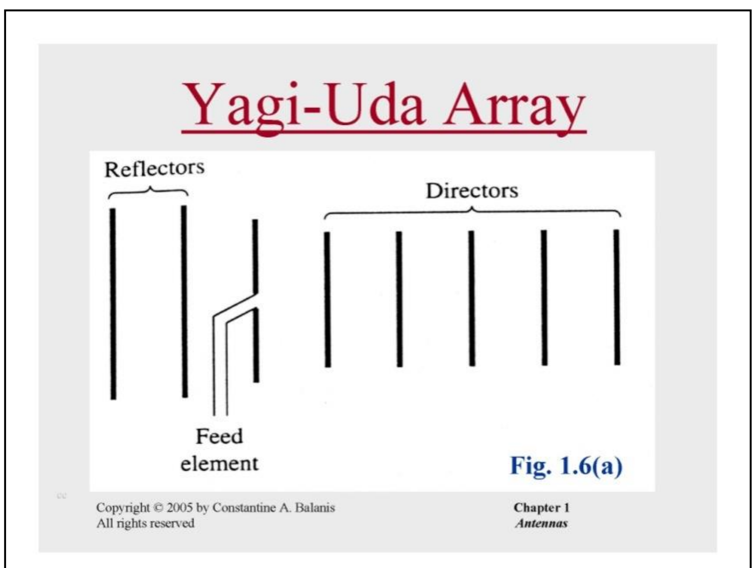
The Yagi antenna consists of a single 'feed' or 'driven' element, typically a dipole antenna.

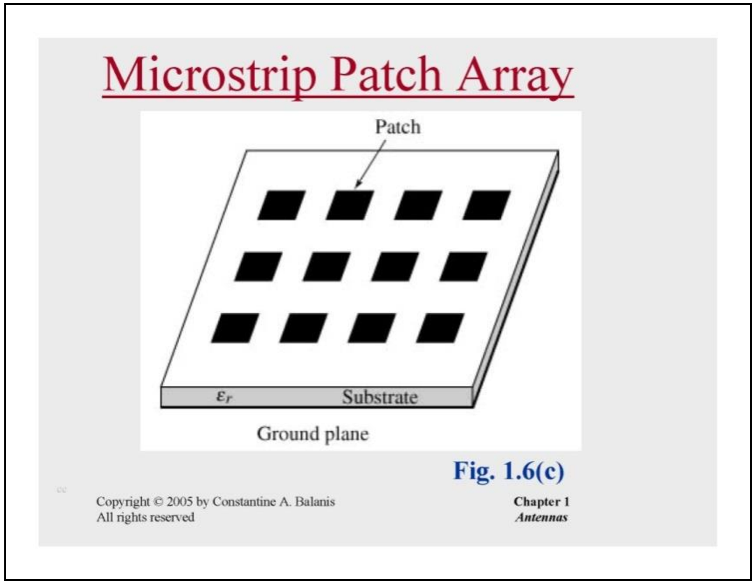
simple construction, high gain over 10 dB.

reflector feeder director



http://www.antenna-theory.com/antennas/travelling/yagi.php




Microstrip Patch Array
Patch
ε_r
Substrate
Ground plane
Fig. 1.6(c)
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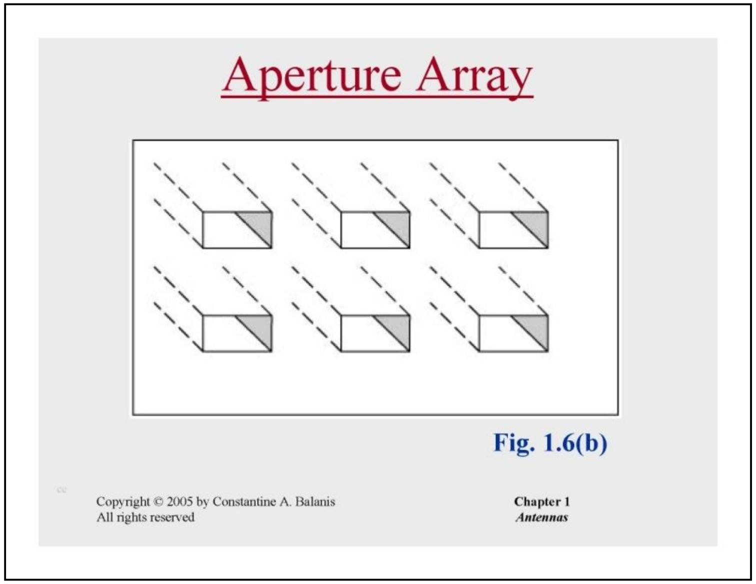
Chapter 1
Antennas


Aperture Array
Fig. 1.6(b)
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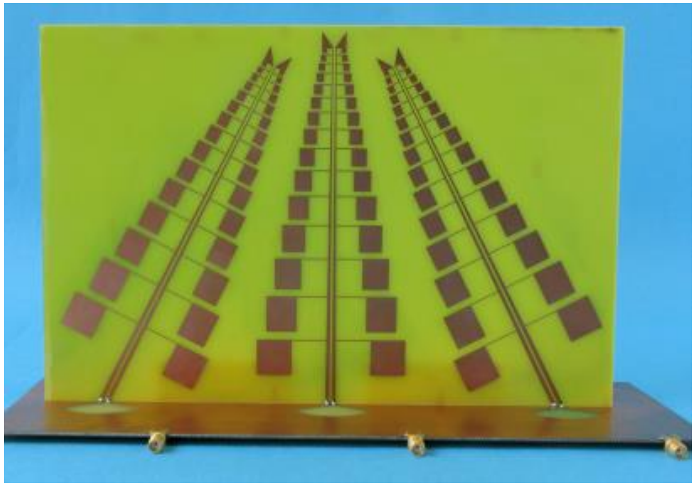
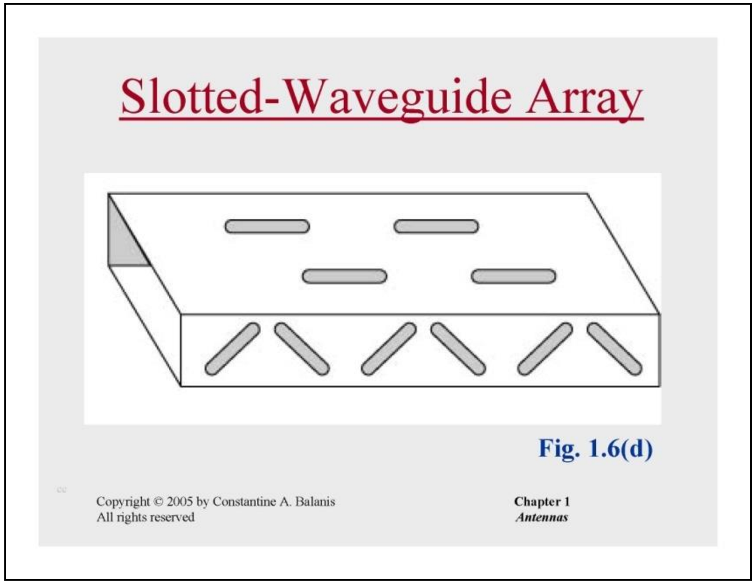
Chapter 1
Antennas




Slotted-Waveguide Array
Fig. 1.6(d)
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Chapter 1
Antennas

Reflector Antennas

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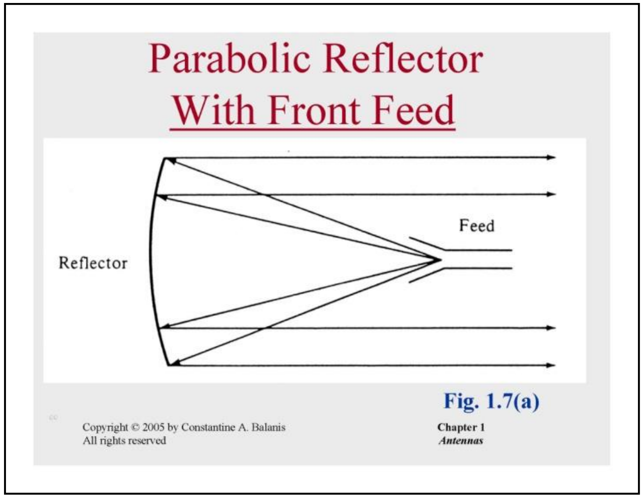
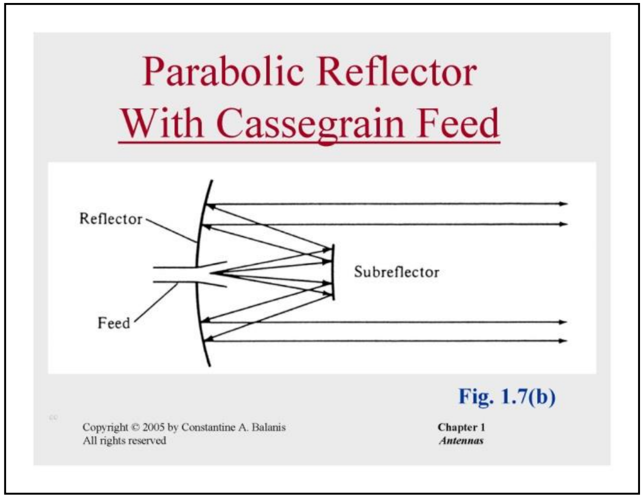
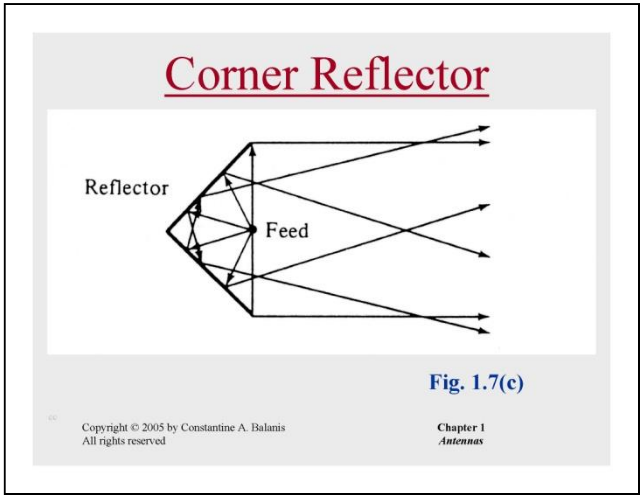
Reflector antennas

- to communicate over great distance

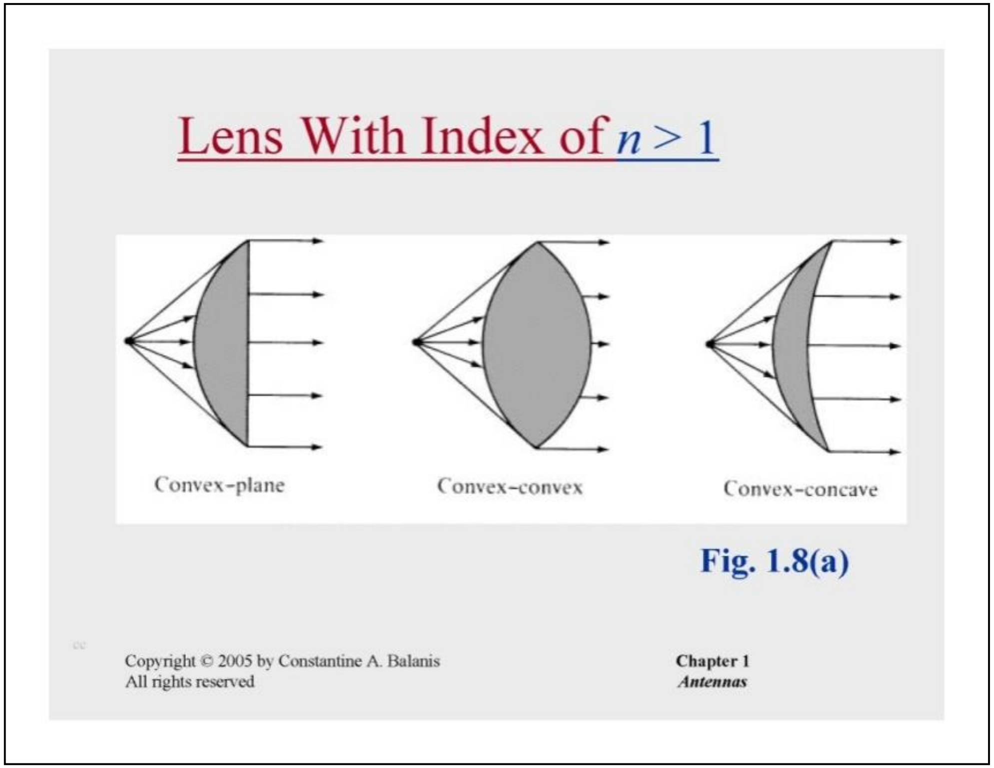






Lens antennas

- Primarily used to collimate incident divergent energy to prevent it from spreading in undesired directions



Radiation mechanisms

How is the radiation accomplished in a single wire?

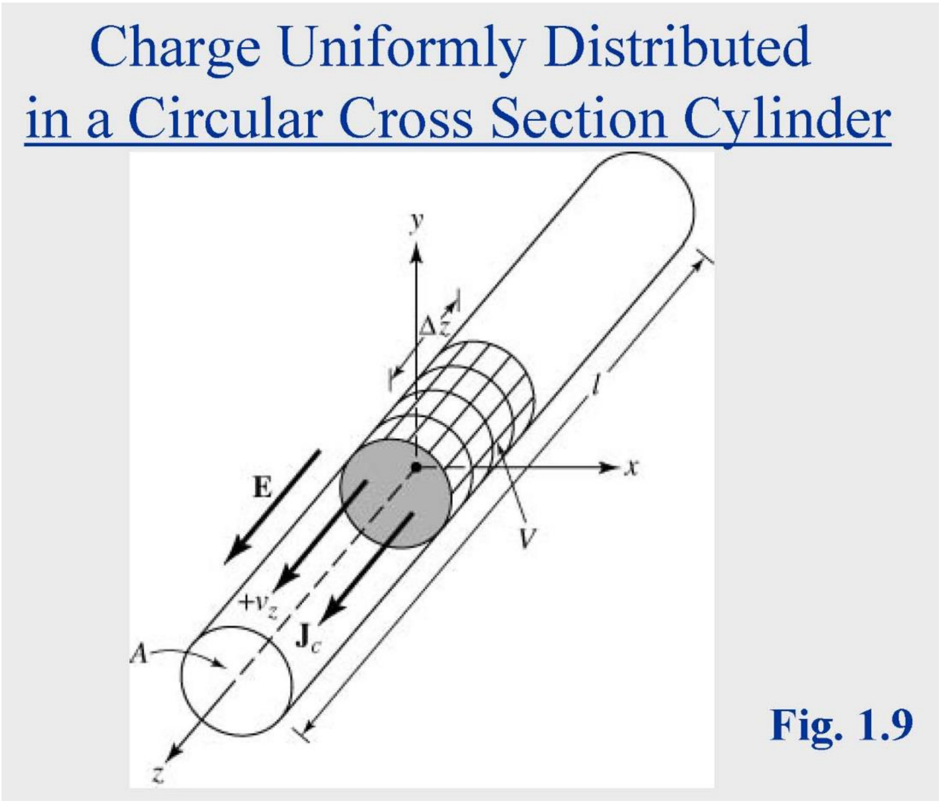


Fig. 1.9

Single wire

- Assume ρ_V is an electric volume charge density (C/m^3) and is uniformly distributed in a circular wire of a cross-sectional *A* and volume *V*.
- The current density $J_z = \rho_V v_z \quad A/m^2$ is called "*convection current.*"
- The current density J_s on the surface is given by $J_s = \rho_s v_z$

where ρ_s is the surface charge density (C/m^2).

If the wire is very thin, then the current can be represented by $I_s = \rho_l v_z$, where ρ_l is the charge per unit length (C/m).

Single wire

$$\frac{dI_z}{dt} = \rho_l \frac{dv_z}{dt} = \rho_l a_z$$

$$\boxed{l \frac{dI_z}{dt} = l\rho_l \frac{dv_z}{dt} = l\rho_l a_z}$$

To create radiation, there must be a time-varying current or an acceleration (or deceleration) of charge).

Radiation facts

1. If a charge is not moving , current is not created and there is no radiation.
2. If charge is moving with a uniform velocity:
   a) There is no radiation if the wire is straight, and infinite in extent.
   b) There is a radiation if the wire is curved, bent, discontinuous, terminated, or truncated.
3. If charge is oscillating in a time-motion, it radiates even if the wire is straight.

Wire configurations for radiation

Curved Wire

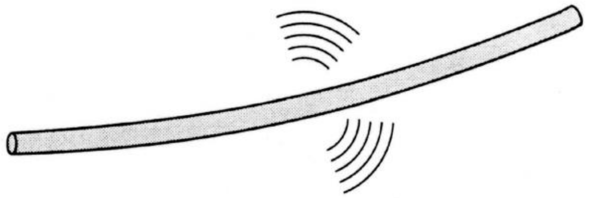


Fig. 1.10(a)

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Bent Wire

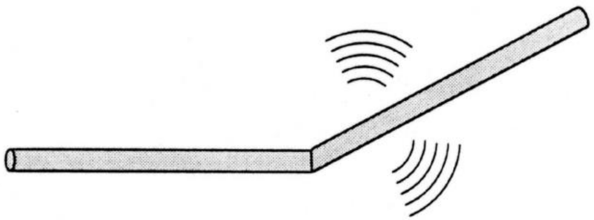

Fig. 1.10(b)

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Discontinuous Wire

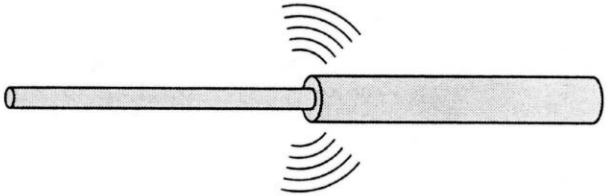

Fig. 1.10(c)

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Two wires

- Applying a voltage source connected to a two-conductor transmission line which is connected to an antenna.

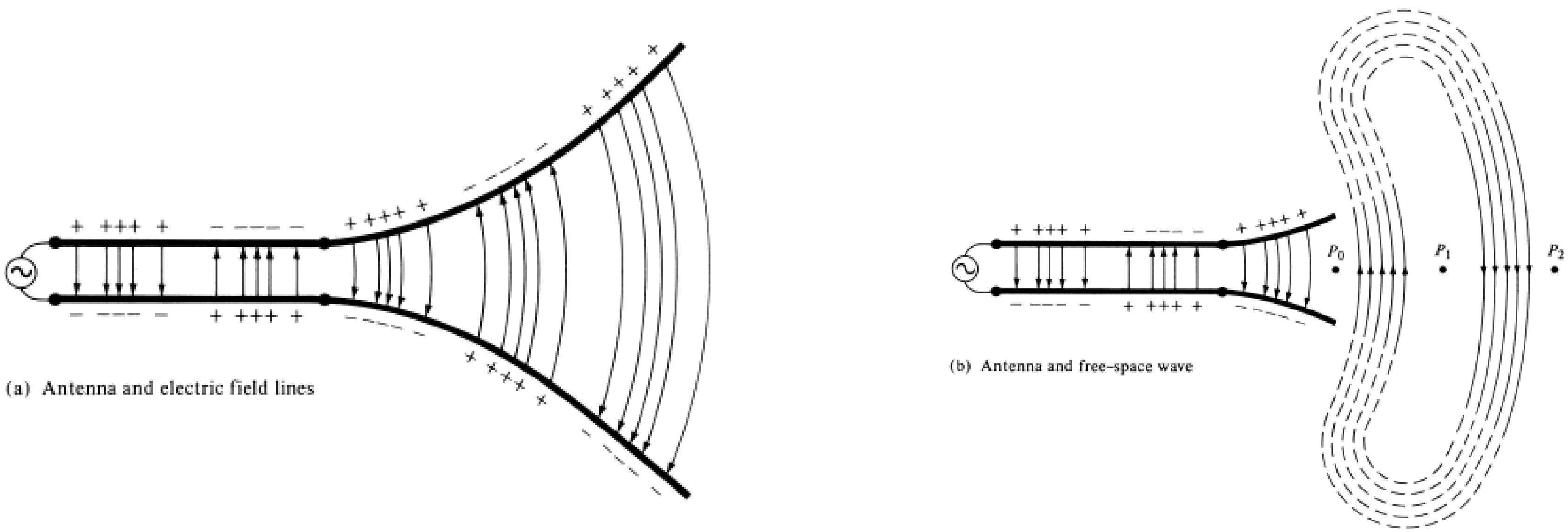
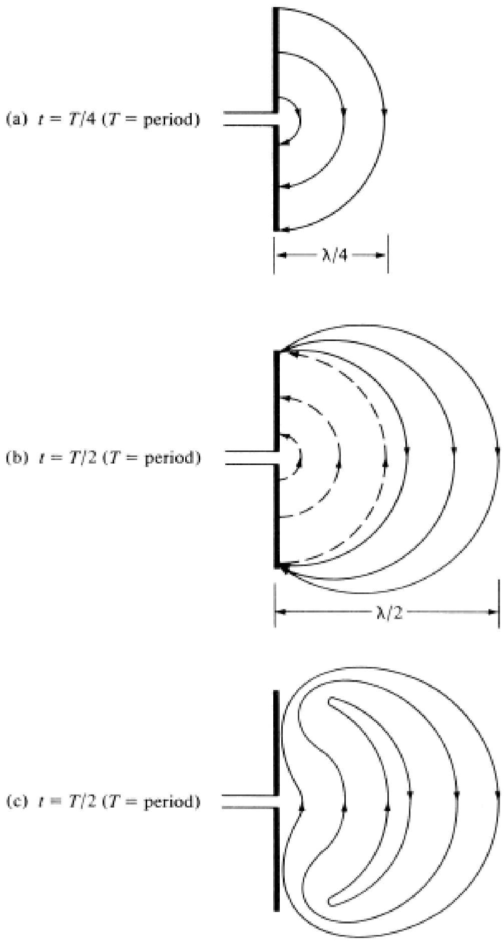


Figure 1.11 Source, transmission line, antenna, and detachment of electric field lines.

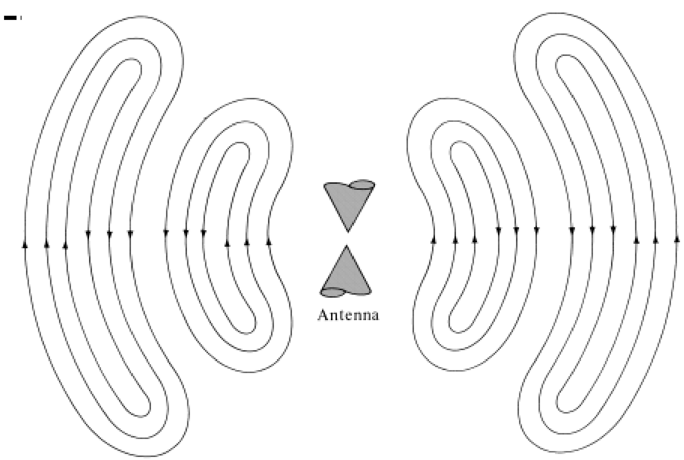
Dipole

The electric lines of force are detached from the antenna to form the free-space waves.



- If the disturbance persists, new waves are continuously created which lag in their travel behind the others.

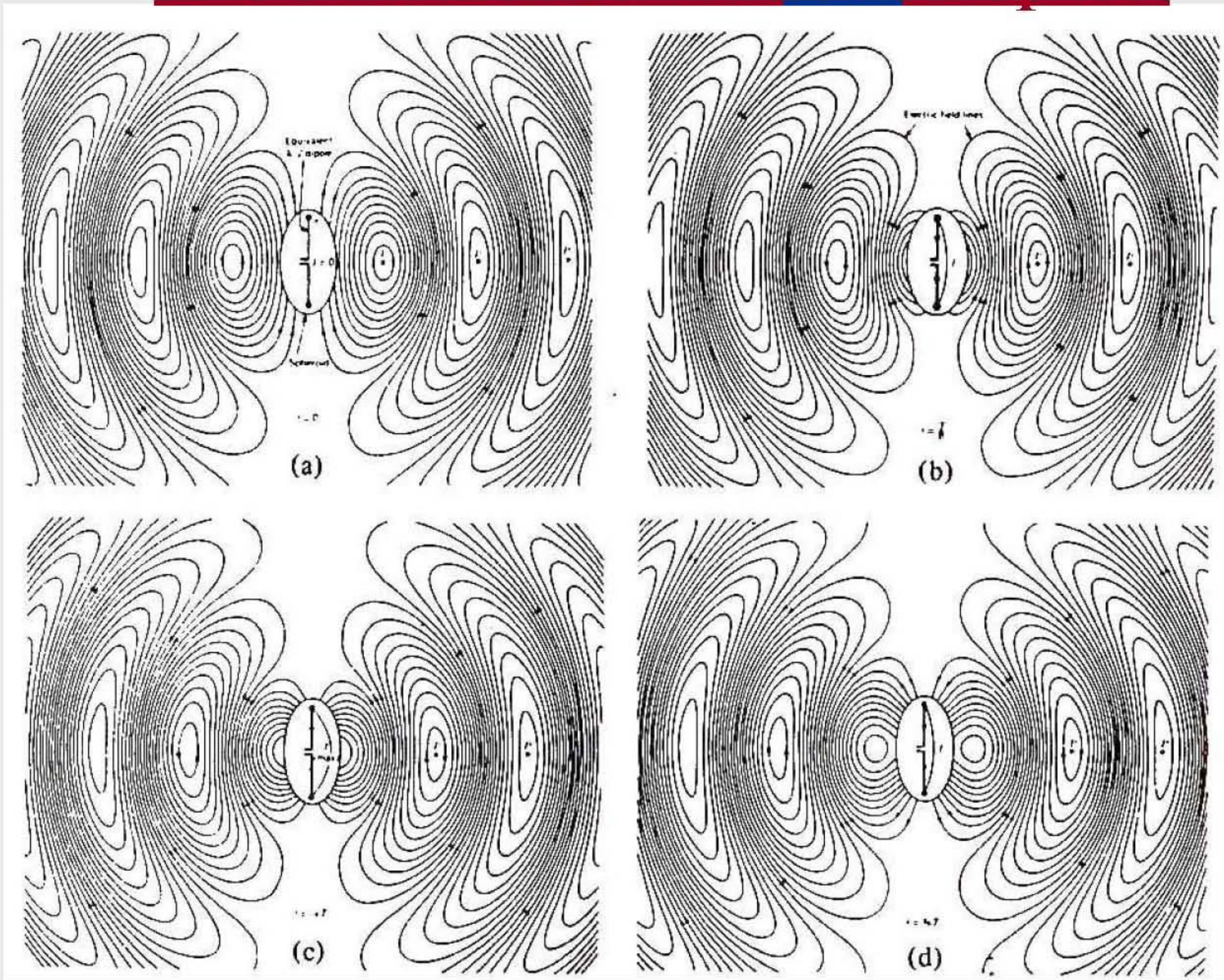
- There is no net charge on the antenna, then the lines of force must have been forced to detach themselves from the conductors and to unite together to form closed loops.



E-Field Lines Of λ/2 Dipole

t=0

t=T/8



t=T/4

t=3T/8

Fig. 1.12

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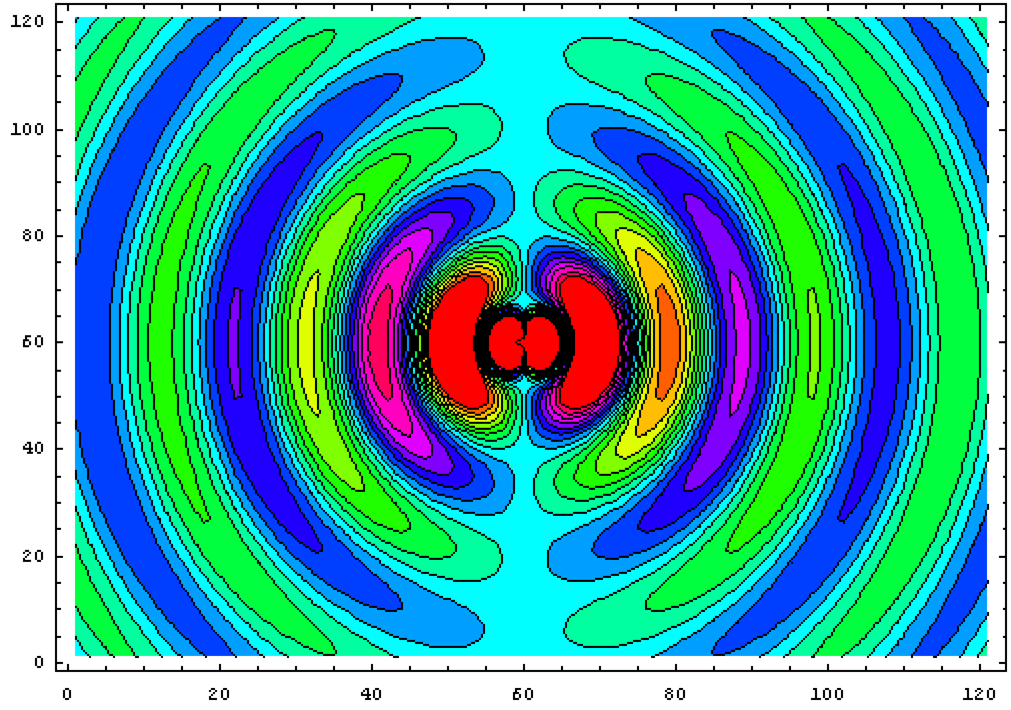
120
100
80
60
40
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0
0
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