CS698T
Wireless Networks: Principles and Practice

Topic 04
Antennas

Bhaskaran Raman,
Department of CSE, IIT Kanpur

http://www.cse.iitk.ac.in/users/braman/courses/wless-spring2007/

Antenna Gain

Antenna Gain G: ratio of transmit/receive power in a particular direction, to that of an isotropic antenna

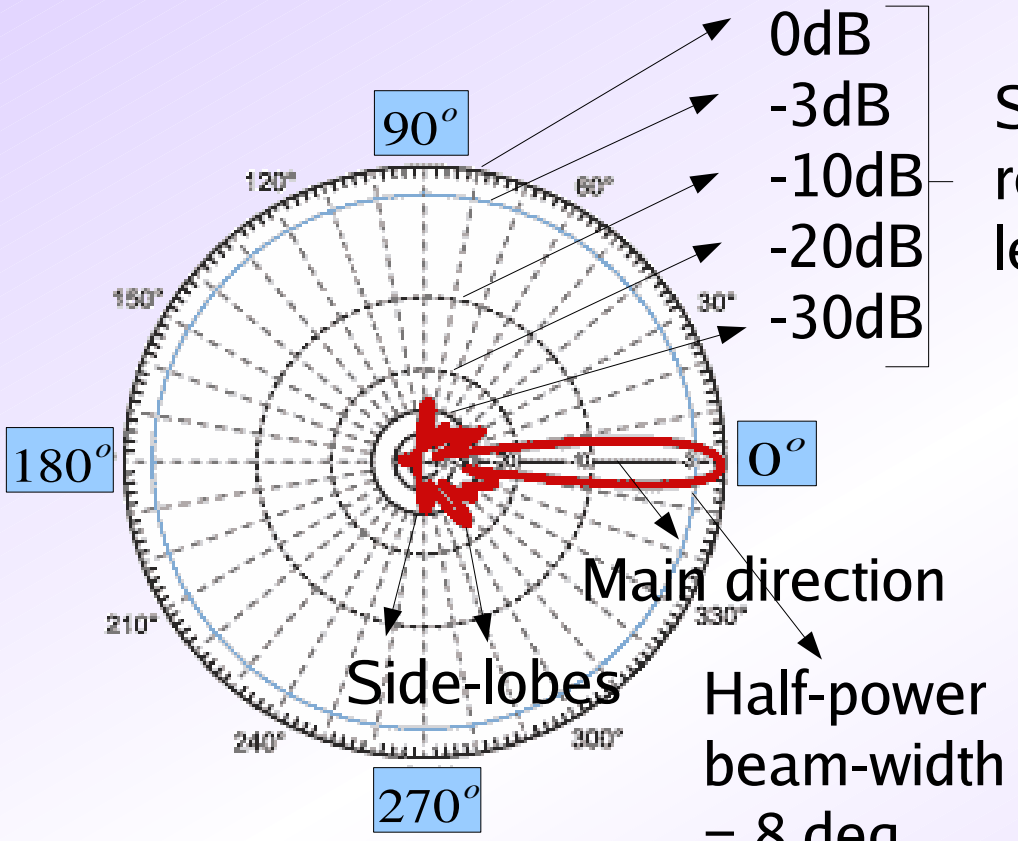
$$G = \frac{P_{directional}}{P_{isotropic}}$$

Transmit gain == Receive gain

Typically, gain is expressed in dBi

$$A_{eff} = \frac{G_r \times \lambda^2}{4 \times \pi}$$

Antenna Radiation Pattern



Parabolic Grid Antenna

Other antennas/patterns:
http://www.hyperlinktech.com/

Some Antenna Terms

- Horizontal vs. Vertical radiation pattern
- Antenna names:
  - Directional, Sector, Omni
- Mechanical specifications (for mounting): dimensions, weight, temp. range, wind loading
- Electrical specifications: impedance, input power

Frii's Free-Space Formula, with Antenna Gain Terms

$$P_r = P_t \times G_t \times G_r \times \left(\frac{\lambda}{4 \times \pi \times d}\right)^2$$

Some more useful forms of the Frii's formula:

$$P_r = P_t \times G_t \times G_r \times \left(\frac{c}{4 \times \pi \times f \times d}\right)^2$$

Free-space path-loss

$$(P_r)_{dBm} = (P_t)_{dBm} + (G_t)_{dB} + (G_r)_{dB} - [32.5 + 20\log_{10}(f) + 20\log_{10}(d)]$$

where f is in MHz and d is in km

Effective Isotropic Radiated Power (EIRP)

http://www.seattlewireless.net/index.cgi/InterpretingFccRegulations

EIRP Regulations: P2MP Links

For **Point-to-Multipoint** links, EIRP = 36 dBm (2.4 Ghz, FCC, USA)

Radio Output	Maximum Allowable Antenna Gain	Example Radios	Example Legal Antennas
15dBm (30mW)	21dBi	Orinoco,	*Omnis, Sectors, Panels, Yagis, Low end parabolics*
20dBm (100mW)	16dBi	Cisco,	*Omnis, some sectors, some yagis, some panels*
23dBm (200mW)	13dBi	Senao,	*Most omnis, some panels*
27dBm (500mW)	9dBi	1/2 watt Amp	*Some omnis, some patches*
30dBm (1 watt)	*6dBi*	*1 watt Amp*	*Some omnis*

Source: http://www.seattlewireless.net/index.cgi/InterpretingFccRegulations

EIRP Regulations: P2P Links

For **Point-to-point** links, 2.4 GHz, FCC, USA

- EIRP is 36dBm for 6dBi antennas
- For every additional 3 dBi, max. transmit power is reduced by 1 dBm

dBi	dBm	EIRP in dBm
6	30	*36*
9	29	*38*
12	28	*40*
15	27	*42*
18	26	*44*
21	25	*46*
24	24	*48*
27	23	*50*
30	22	*52*
...	...	...

Source: http://www.seattlewireless.net/index.cgi/InterpretingFccRegulations

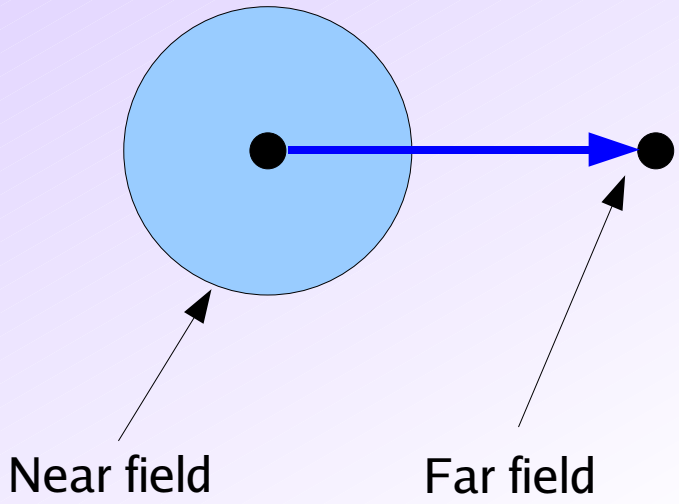
EIRP Regulations in India

- For 2.4 GHz, likely the same as in FCC (USA)
- See:
  - Ministry of Communications and Information Technology, Wireless Planning and Coordination Wing
    NOTIFICATION
    New Delhi, the 28th January, 2005
  - Gazette-2.4GHz-Outdoor.doc

Antenna Polarization

- Polarization: the orientation of the E-plane (electric field)
- Tx and Rx antenna should use the same polarization
  - 45 deg mismatch ==> 3 dB loss
  - 90 deg mismatch ==> up to 20 dB loss

Near Field and Far Field



$$P_r = P_t \times G_t \times G_r \times \left(\frac{\lambda}{4 \times \pi \times d}\right)^2$$

Valid only when

$$d > d_f = \frac{2 \times D^2}{\lambda}$$

D is the largest dimension of the antenna

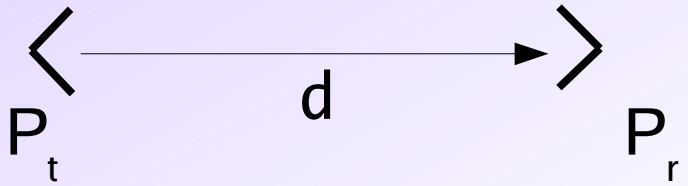
Example: what is the near-field of the parabolic grid antenna shown earlier?

$D = 1\text{m}$

$f = 2.4\ GHz$

$$d_f = \frac{2 \times 1^2}{0.125} = 16\text{m}$$

Path Loss Example



$P_t = 50\text{mW}$, 2.4GHz *transmission*, $d = 2\text{km}$, $P_r = ?$

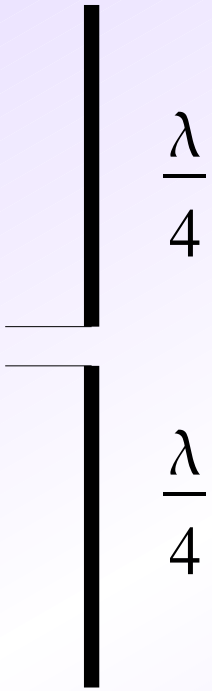
$$PathLoss = 32.5 + 20\log_{10}(2400) + 20\log_{10}(2) \simeq 106\text{dB}$$

$$P_r = P_t - PathLoss = 17\text{dBm} - 106\text{dB} = -89\text{dBm}$$

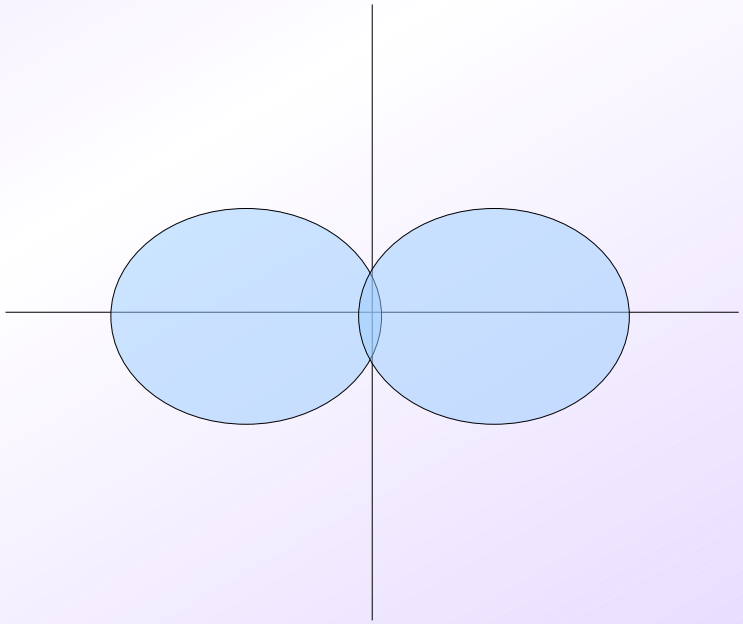
$G_t = 24\text{dBi}$, $G_r = 24\text{dBi}$, $P_r = ?$

$$-89\text{dBm} + 24\text{dB} + 24\text{dB} = -41\text{dBm}$$

A Simple Antenna Design



Dipole Antenna



Radiation Pattern