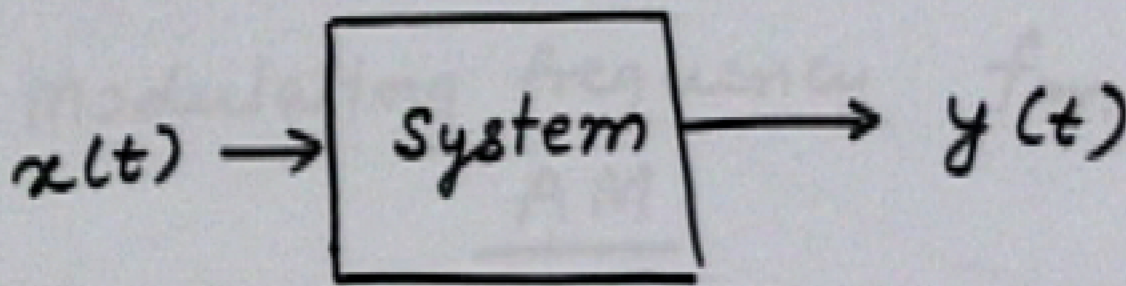



$$y(t) = A\,x(t-\tau)$$

$$Y(\omega) = A\,X(\omega)\,e^{j\tau\omega}$$

Amp. response constant

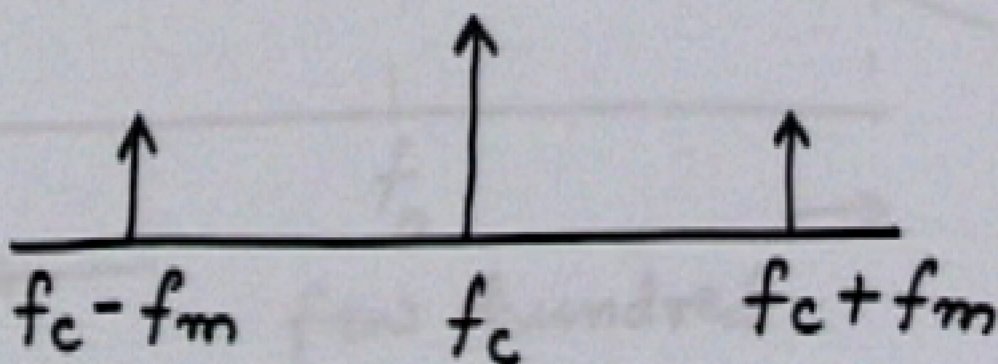
Phase response Linear.

Radio frequency :

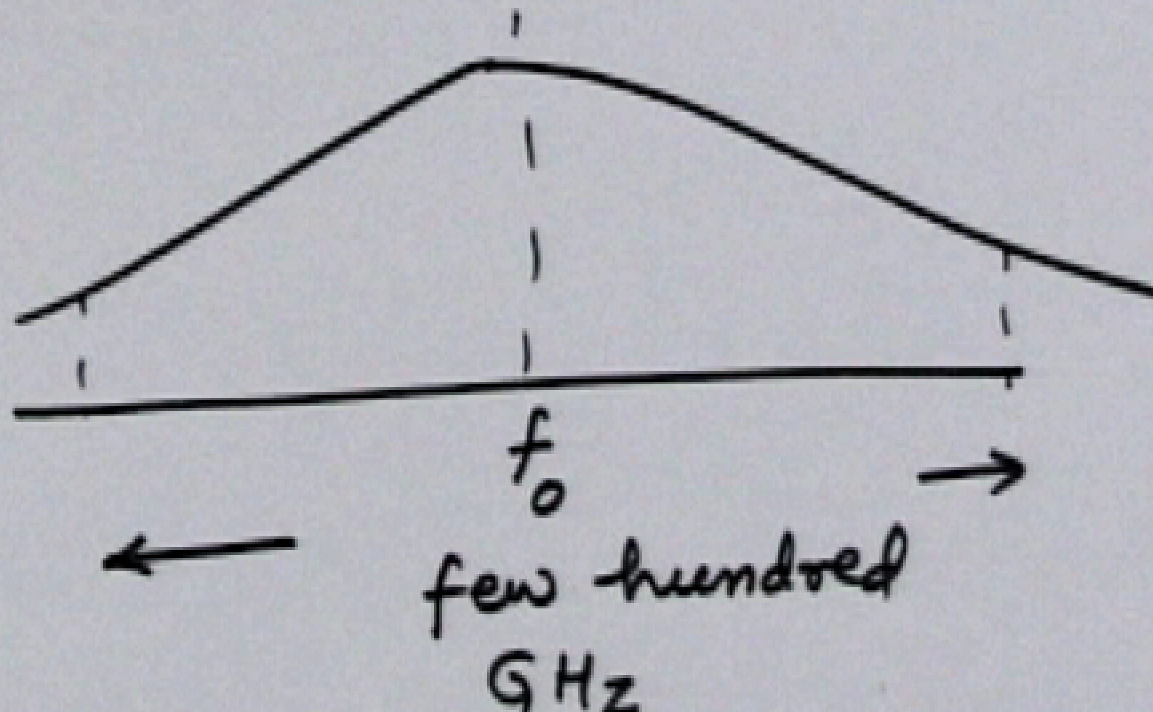
carrier → $f_c$

modulating frequency $f_m$

<u>AM</u>



1 nm ~ 100 GHz



# Signal Distortion

- **Dispersion**
  - Material
  - Intramodal
  - Intermodal

    ( Multi-mode only)

- **Attenuation**
  - Material
    - Absrption
    - Scattering $\sim \lambda^{-4}$

    Micro-bending

    Radiation

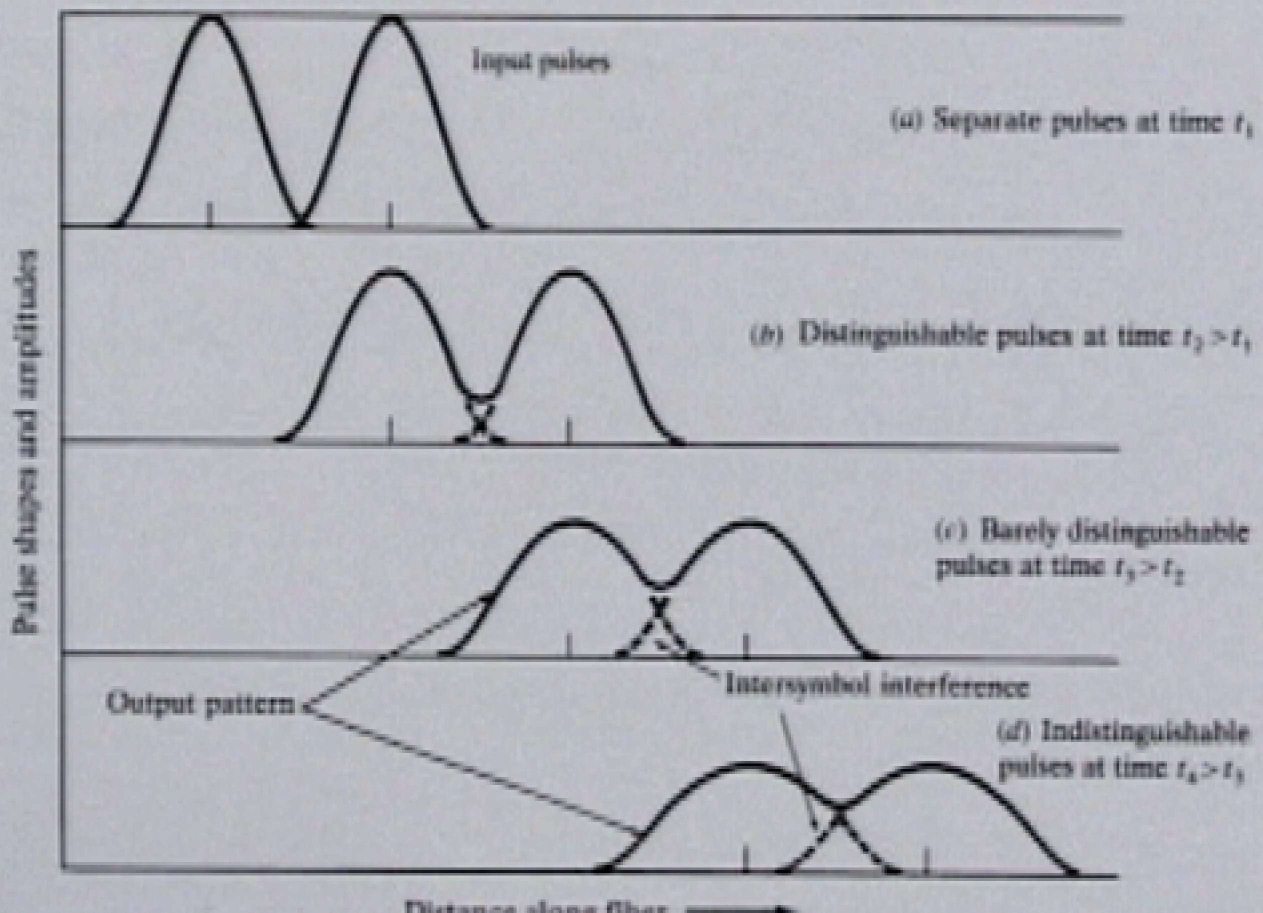
    (Macro-bending)

$$f_c \sim 10^{14} \text{ Hz}$$

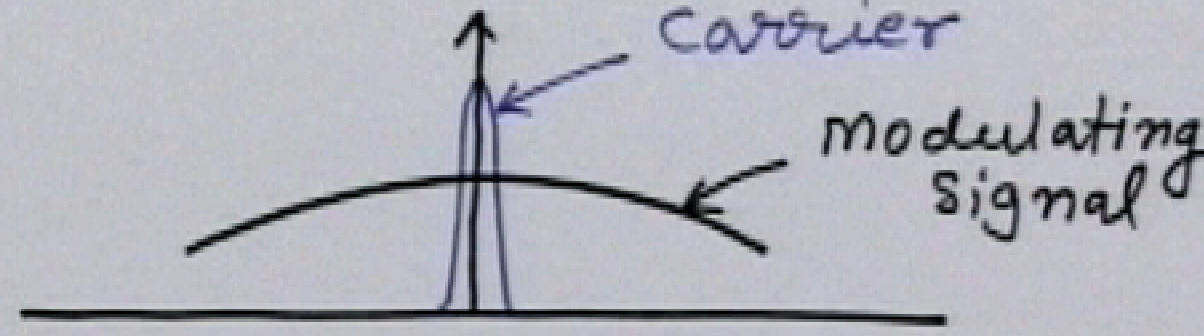
$$f_m \sim 10^{10} \text{ Hz} \quad (10 \text{ GHz})$$

$$Q = \frac{10^{14}}{10^{10}} = 10^4$$

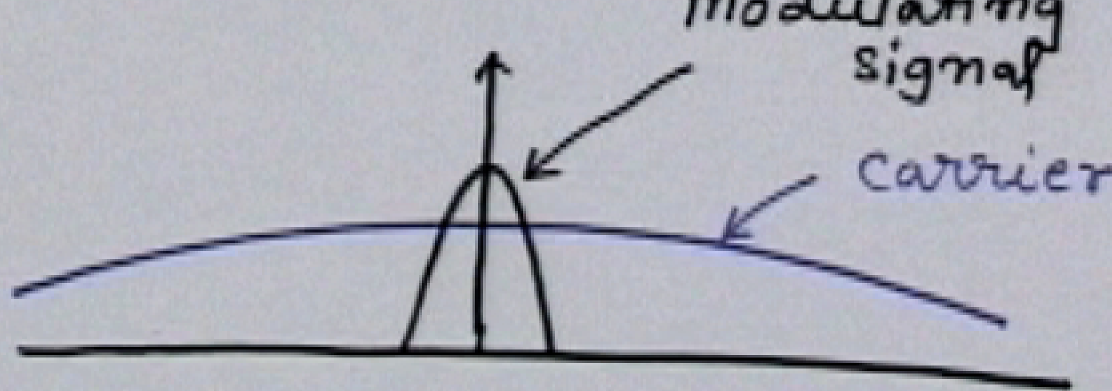
# Pulse broadening and attenuation

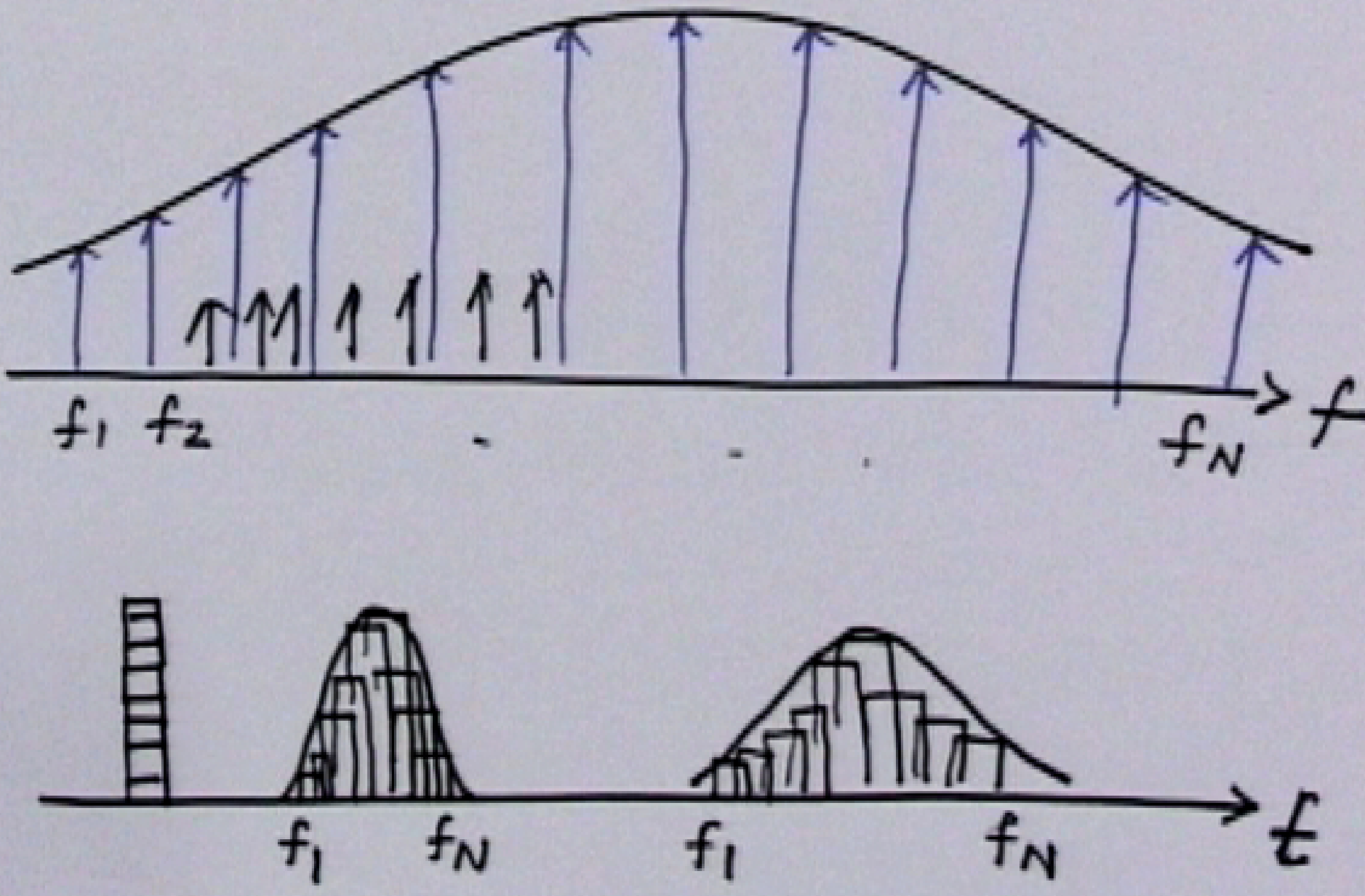


Radio System :




Optical System :





f1 f2
fN
f
f1 fN
f1 fN
t

# Dispersion

Group Velocity $v_g = \frac{\partial \omega}{\partial \beta} = 2\pi c \frac{\partial}{\partial \beta}(1/\lambda)$

Group Delay per unit length $t_g = 1/v_g$

Pulse Broadening $\tau_g = \frac{dt_g}{d\lambda}\sigma_\lambda = -\frac{\sigma_\lambda}{2\pi c}\left\{2\lambda \frac{d\beta}{d\lambda} + \lambda^2 \frac{d^{2\beta}}{d\lambda^2}\right\}$

Dispersion $D = \frac{dt_g}{d\lambda}$ = Pulse broadening per unit distance per unit spectral width ( ps/Km/nm)

Phase constant

$$\beta = \frac{2\pi}{\lambda} n(\lambda)$$

$$\rightarrow \quad t_g = \frac{\partial \beta}{\partial \omega}$$

$$D = \frac{d t_g}{d\lambda}$$

$$D_{mat} = -\frac{\lambda}{c} \frac{d^2 n}{d\lambda^2}$$

# Material Dispersion

$$D_{mat} = -\frac{\lambda}{c}\frac{d^2 n}{d\lambda^2}$$

| Wavelength λ | D mat ps/Km/nm |
|---|---|
| 850 nm | 85 |
| 1310 nm | 0.1 |
| 1550 nm | -20 |