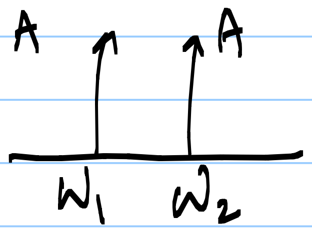
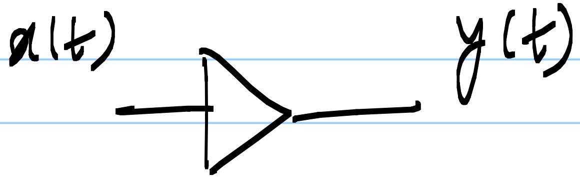
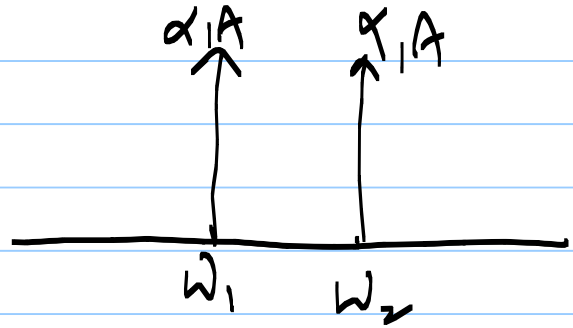
29/1/20

Lec 8







$$x(t) = A\cos\omega_1 t + A\cos\omega_2 t$$

$$y(t) = \underbrace{\alpha_0}_{DC} + \underbrace{\alpha_1 x(t)}_{fund.} + \alpha_2 x^2(t) + \alpha_3 x^3(t) \quad \ldots$$

$$DC = \alpha_0 + \cancel{(\;)}$$

$$\text{fundamental component} = \alpha_1 A\cos\omega_1 t + \alpha_1 A\cos\omega_2 t$$

$$\alpha_2 x^2(t) = \alpha_2 A^2 (\cos\omega_1 t + \cos\omega_2 t)^2$$

$$= \alpha_2 A^2 (\cos^2\omega_1 t + \cos^2\omega_2 t + 2\cos\omega_1 t\cos\omega_2 t)$$

2nd harm. of ω_1 $\leftarrow$ $\frac{1+\cos 2\omega_1 t}{2}$

$2\omega_2$ — $\frac{1+\cos 2\omega_2 t}{2}$

$\cos(\omega_1+\omega_2)t + \cos(\omega_2-\omega_1)t$

$\cos(\omega_1+\omega_2)t + \cos(\omega_2-\omega_1)t \rightarrow$ 2nd order

$IM_2 \leftarrow$ intermodulation terms

$p\omega_1 \pm q\omega_2 \rightarrow IM_2, IM_3, IM_4$ etc.

depending on p & q

IM_k where $p+q=k$

$$\alpha_3 x^3(t) = \alpha_3 A^3(\cos\omega_1 t + \cos\omega_2 t)^3$$

$$= \alpha_3 A^3\left[\cos^3\omega_1 t + \cos^3\omega_2 t + 3\cos^2\omega_1 t\cdot\cos\omega_2 t + 3\cos\omega_1 t\cos^2\omega_2 t\right]$$

$$\frac{3\cos\omega_1 t + \cos 3\omega_1 t}{4} \qquad \frac{3\cos\omega_2 t + \cos 3\omega_2 t}{4}$$

other terms:

$$3\cos\omega_2 t\left(\frac{1+\cos 2\omega_1 t}{2}\right) + 3\cos\omega_1 t\left(\frac{1+\cos 2\omega_2 t}{2}\right)$$

$$\frac{3}{2}\cos(2\omega_1 t)\cos(\omega_2 t)$$

$$= \frac{3}{4}\left[\cos(2\omega_1 \pm \omega_2)t\right]$$

$$\frac{3}{4}\left[\cos(2\omega_2 \pm \omega_1)t\right]$$

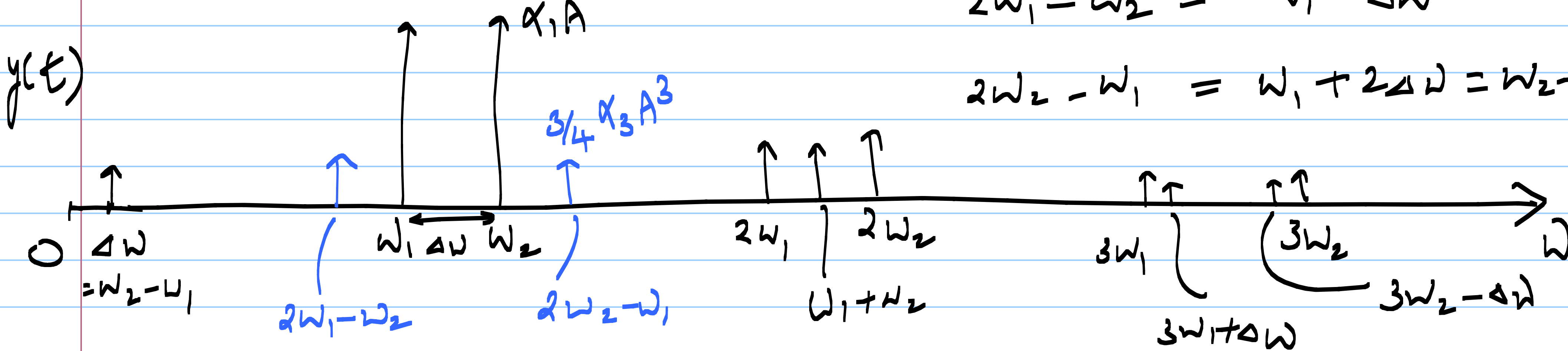
IM3 components

$$2\omega_1 + \omega_2 = 3\omega_1 + \Delta\omega$$

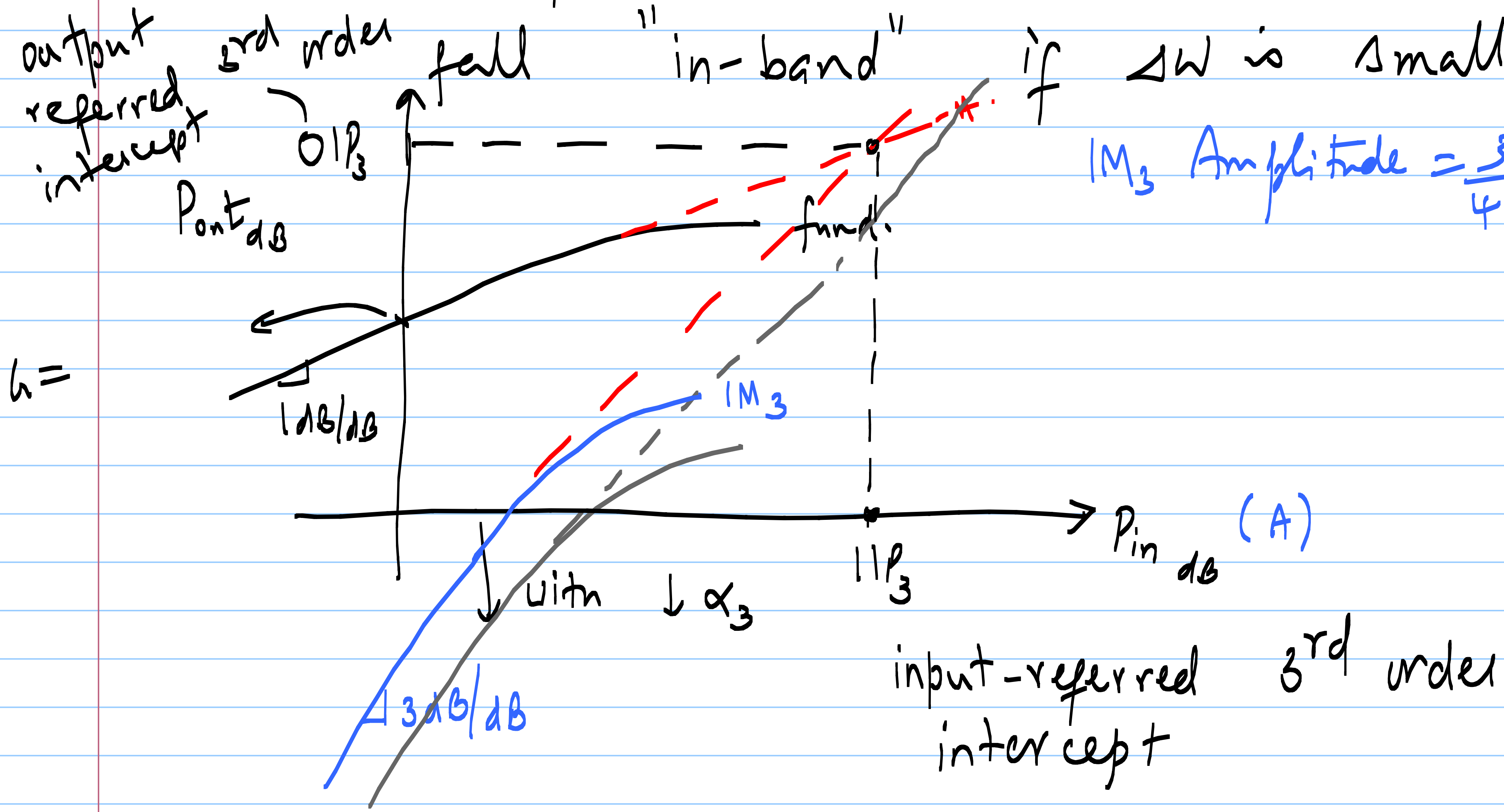
$$2\omega_2 + \omega_1 = 3\omega_2 - \Delta\omega$$

$$2\omega_1 - \omega_2 = \omega_1 - \Delta\omega$$

$$2\omega_2 - \omega_1 = \omega_1 + 2\Delta\omega = \omega_2 + \Delta\omega$$



IM_3 components @ $2\omega_2-\omega_1$ & $2\omega_1-\omega_2$ fall "in-band" if $\Delta\omega$ is small



IM_3 Amplitude $= \frac{3}{4}\alpha_3 A^3$

Procedure to measure IIP_3: (2-tone test)

* Apply 2 tones ω_1 & ω_2 of equal amplitudes A
* choose $\Delta\omega = \omega_2 - \omega_1$ to be small
* choose A to be small
* Plot P_{out} vs P_{in} in dB
  - ↳ fundamental curve is linear with slope 1 dB/dB
  - ↳ IM_3 curve is linear with slope 3 dB/dB
* extrapolate linear portions to meet @ (IIP_3, OIP_3)

fundamental @ output $= \alpha_1 A$

IM_3 @ output $= \frac{3}{4} \alpha_3 A^3$

$$\alpha_1 A_{IP_3} = \frac{3}{4} \alpha_3 A_{IP_3}^3$$

amplitude $A_{IP_3} = \sqrt{\frac{4}{3} \left|\frac{\alpha_1}{\alpha_3}\right|}$

power $IIP_3 = \frac{2}{3} \left|\frac{\alpha_1}{\alpha_3}\right| \cdot \frac{1}{R_s}$