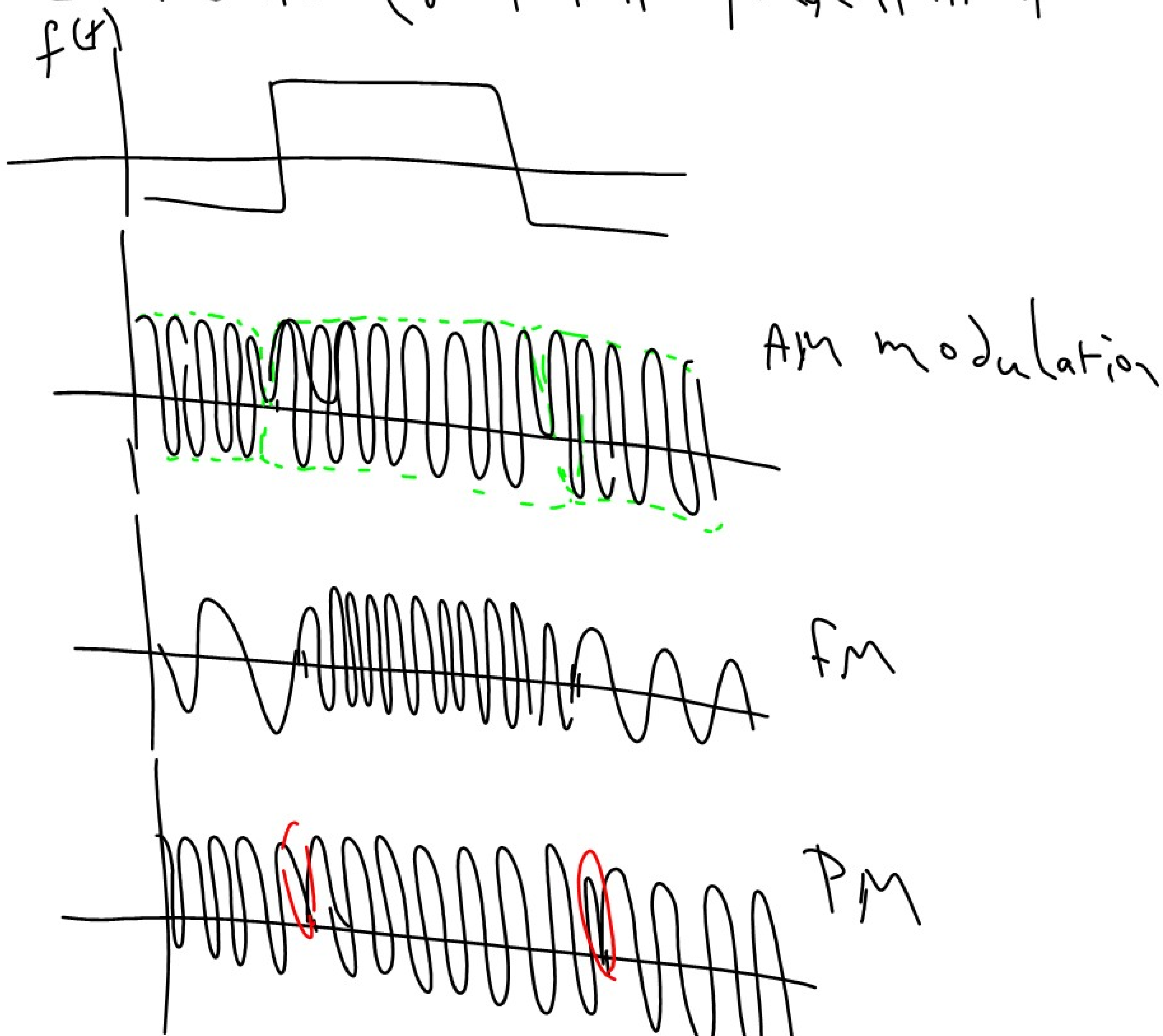
Angle modulation

* In the previous chapter, we have seen that in amplitude modulation the amplitude of the carrier was varied to according to the information signal.
* In this chapter, we will change the frequency of the carrier according to the information signal and this type of modulation is known as frequency modulation (FM)
* alternatively we can change the phase of the carrier according to the information signal and this modulation type is known as phase modulation (PM)
* a comparison between AM, FM and PM is shown below (graphical representation)



FM

* In FM the frequency of the carrier is altered linearly according to the information signal
* This means that the angular frequency of the carrier can be written as

$$w_1 = w_c + k_f f(t)$$

where k_f is the frequency modulation constant

If for example $f(t) = a\cos w_m t$, then

$$w_1 = w_c + ak_f \cos w_m t$$

* The term ak_f is known as peak frequency deviation which is denoted by $\Delta w = ak_f = w_1 - w_c$
* recall that the carrier equation is given by

$$c(t) = A\cos\theta(t)$$

* The angle of the carrier is related to the instantaneous frequency w_1 by

$$w_1 = \frac{d\theta(t)}{dt} \Longrightarrow \theta(t) = \int w_1(\tau)\,d\tau + \theta_0$$

where θ_0 is the initial phase of the carrier

Now

$$\theta(t) = w_c t + k_f \int_0 f(t)\,dt + \theta_0$$

$$= w_c t + \frac{ak_f}{w_m}\sin w_m t + \theta_0$$

The term $\frac{ak_f}{w_m} = \frac{\Delta w}{w_m} = \beta$ which is known as the modulation index

$$\therefore \ \phi_{FM}(t) = A\cos(w_c t + \beta\sin w_m t + \theta_0)$$

* The above expression is a special case of FM when $f(t) = a\cos w_m t$
* In general

$$\phi_{FM}(t) = A\cos\left(w_c t + k_f \int_0^t f(\tau)\,d\tau + \theta_0\right)$$