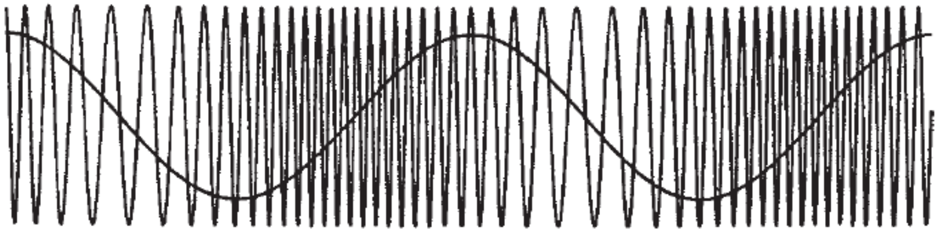
Phase Modulation

Figure 39

(a)

When $m(t)$ and hence the phase of $x_{\mathrm{PM}}(t)$ change **continuously**, it is difficult to see the connection with the actual plot of $x_{\mathrm{PM}}(t)$.

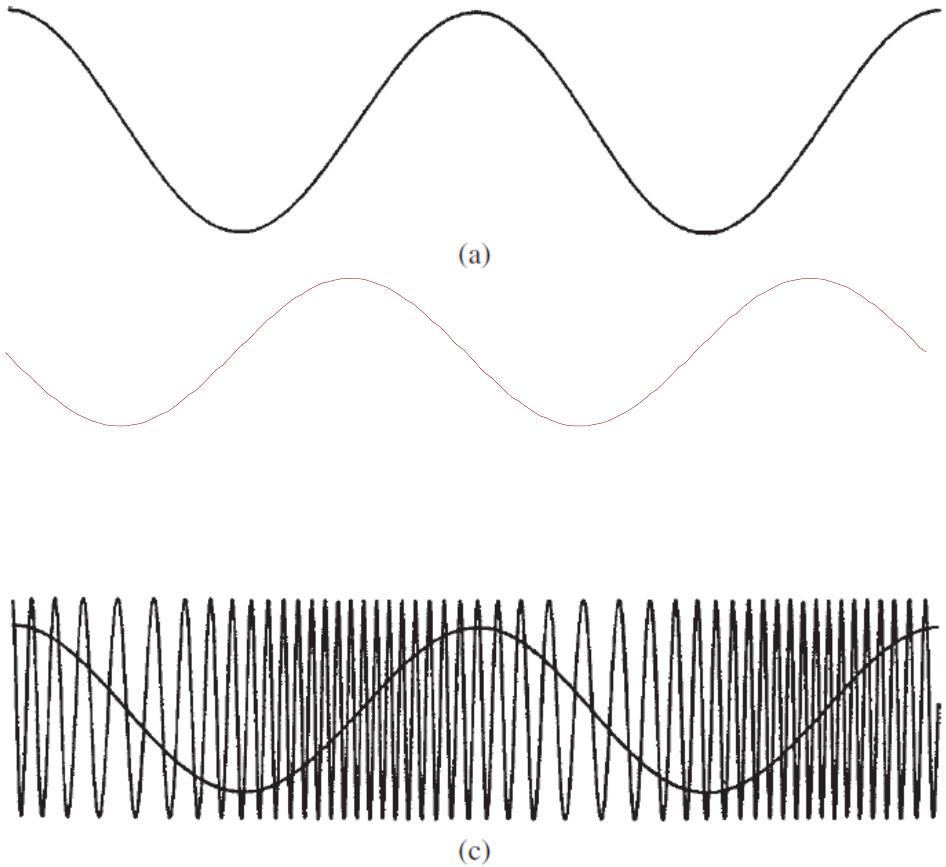


(c)

New Fact: In $x_{\mathrm{PM}}(t)$, the **instantaneous frequency** varies in proportion with the **slope** of $m(t)$.

Phase Modulation

Figure 39



$m(t)$

$\frac{d}{dt}m(t)$

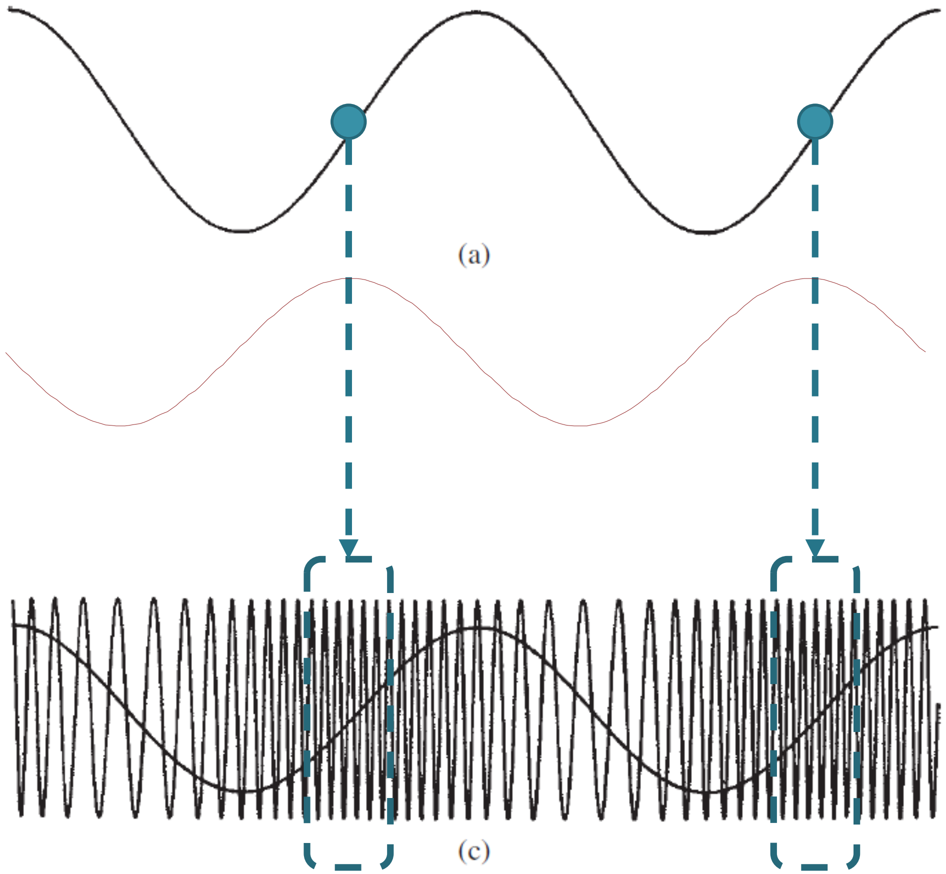
$x_{\mathrm{PM}}(t)$

$$f(t) = f_c + k_p \frac{d}{dt} m(t)$$

New Fact: In $x_{\mathrm{PM}}(t)$, the **instantaneous frequency** varies in proportion with the **slope** of $m(t)$.

Phase Modulation

Figure 39

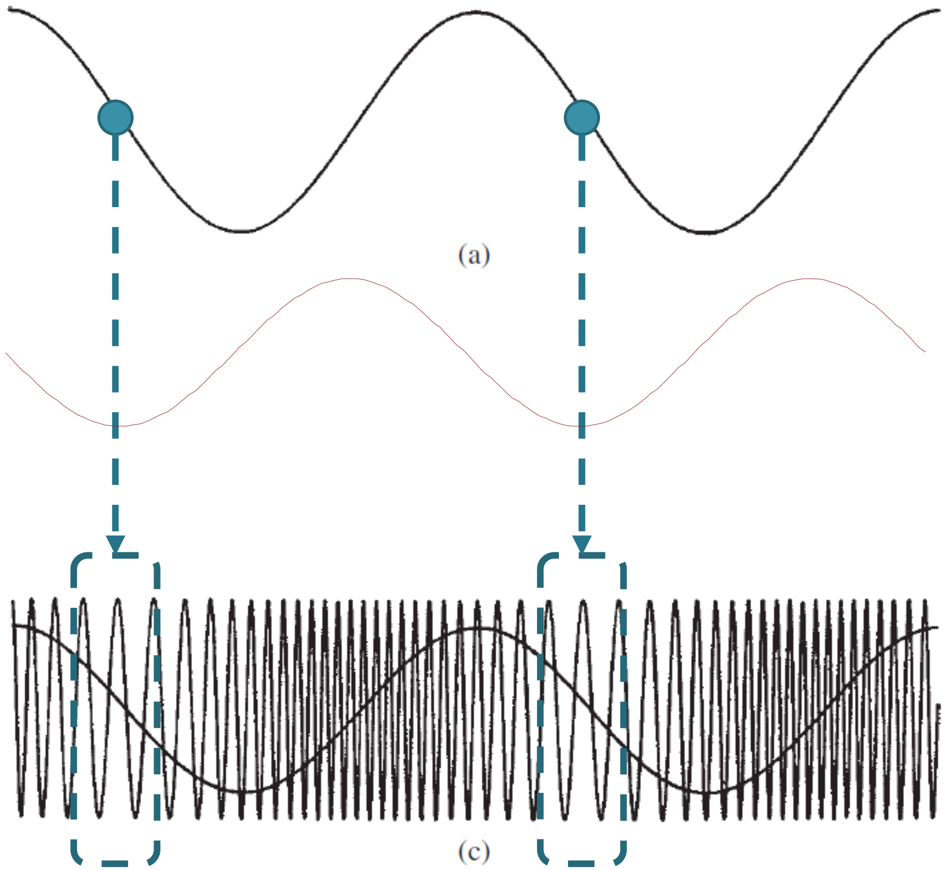


The time at which the **slope** of $\boldsymbol{m(t)}$ is at its **maximum** value corresponds to the time at which $\boldsymbol{x_{\text{PM}}(t)}$ has **maximum frequency**.

New Fact: In $x_{\text{PM}}(t)$, the **instantaneous frequency** varies in proportion with the **slope** of $m(t)$.

Phase Modulation

Figure 39

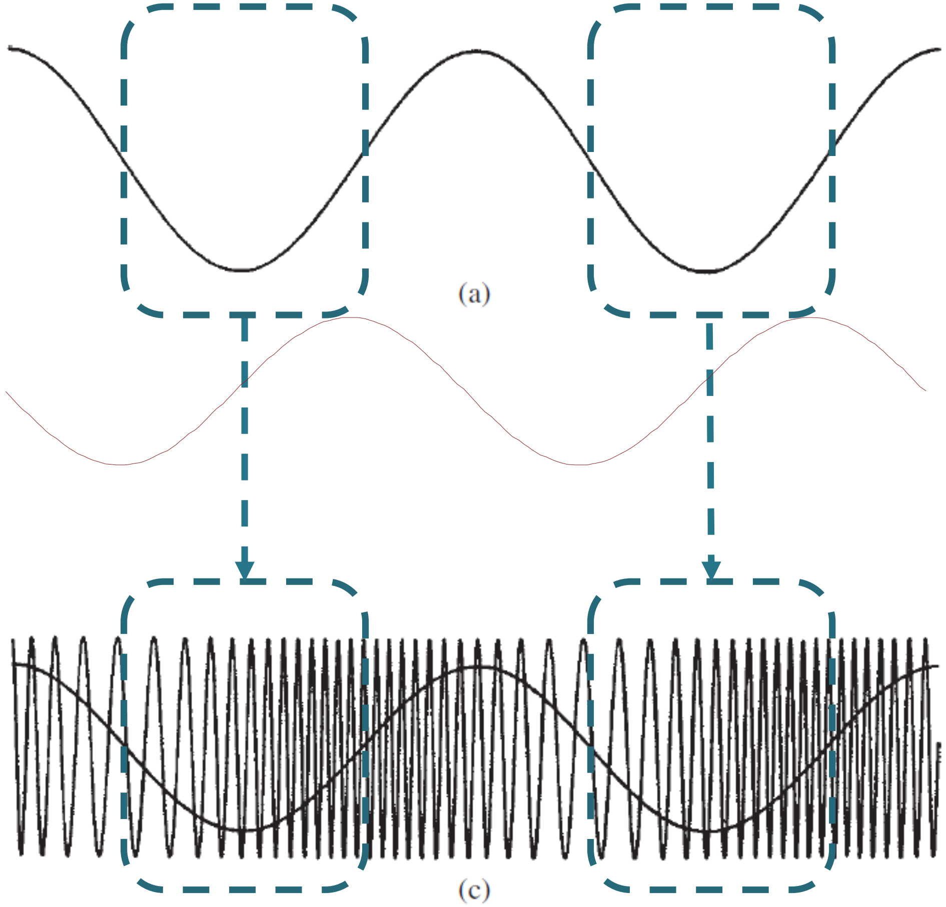


The time at which the **slope** of $\boldsymbol{m(t)}$ is at its **minimum** value corresponds to the time at which $\boldsymbol{x_{\mathrm{PM}}(t)}$ has **minimum frequency**.

New Fact: In $x_{\mathrm{PM}}(t)$, the **instantaneous frequency** varies in proportion with the **slope** of $m(t)$.

Phase Modulation

Figure 39



$m(t)$

$\frac{d}{dt}m(t)$

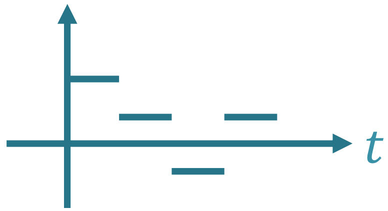
$x_{PM}(t)$

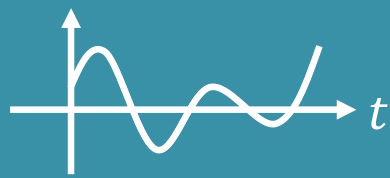
The time interval during which the **slope** of $\boldsymbol{m(t)}$ is **increasing** corresponds to the time interval during which $\boldsymbol{x_{PM}(t)}$ has **increasing frequency**.

New Fact: In $x_{PM}(t)$, the **instantaneous frequency** varies in proportion with the **slope** of $m(t)$.

AM, PM, and FM

- Sinusoidal Carrier: $A\cos(2\pi f_c t + \phi)$



Band-limited to B Bounded by $\pm m_p$ **Analog $m(t)$** 	**Digital $m(t)$** **$m(t)$ is piecewise constant. Its values are selected from a collection of M possibilities.)**
AM: $x_{\text{AM}}(t) = \left(A + m(t)\right)\cos(2\pi f_c t + \phi)$	ASK
PM: $x_{\text{PM}}(t) = A\cos\left(2\pi f_c t + \phi + k_p m(t)\right)$ $\downarrow \frac{1}{2\pi}\frac{d}{dt}$ Useful for plotting $x_{\text{PM}}(t)$ over the time intervals where $m(t)$ is differentiable. $f(t) = f_c + \frac{k_p}{2\pi}\frac{d}{dt}m(t)$	PSK
FM: $x_{\text{FM}}(t) = A\cos\left(2\pi f_c t + \phi + 2\pi k_f \int_{-\infty}^{t} m(\tau)d\tau\right)$ $\uparrow 2\pi\int$ $f(t) = f_c + k_f m(t)$	FSK