$$x(t) = a_1 p_1(t) + a_2 p_2(t)$$

$\pm A$ $\pm A$

$$x(t) = \begin{cases} A\,p_1(t) + A\,p_2(t) \\ A\,p_1(t) - A\,p_2(t) \\ -A\,p_1(t) + A\,p_2(t) \\ -A\,p_1(t) - A\,p_2(t) \end{cases}$$

4 Possible waveforms.

Consider $A p_1(t) + A p_2(t)$

$$= A \cdot \sqrt{\frac{2}{T}} \cos(2\pi f_c t) + A \cdot \sqrt{\frac{2}{T}} \cdot \sin(2\pi f_c t)$$

$$= \frac{A}{} \cdot \sqrt{\frac{2}{T}} \left\{ \cos(2\pi f_c t) + \sin(2\pi f_c t) \right\}$$

$$= A \cdot \frac{2}{\sqrt{T}} \left\{ \frac{1}{\sqrt{2}} \cos(2\pi f_c t) + \frac{1}{\sqrt{2}} \sin(2\pi f_c t) \right\}$$

$$= A \cdot \frac{2}{\sqrt{T}} \left\{ \cos\frac{\pi}{4} \cos(2\pi f_c t) + \sin\left(\frac{\pi}{4}\right) \sin(2\pi f_c t) \right\}$$

$$= \frac{2A}{\sqrt{T}} \cdot \cos\left(2\pi f_c t - \frac{\pi}{4}\right)$$

waveform 1

$A p_1(t) + A p_2(t)$

$$A p_1(t) - A p_2(t)$$

$$= A \cdot \sqrt{\frac{2}{T}} \left\{ \cos(2\pi f_c t) - \sin(2\pi f_c t) \right\}$$

$$= A\cdot\frac{2}{\sqrt{T}}\left\{\cos\left(\frac{\pi}{4}\right)\cos(2\pi f_c t) - \sin\left(\frac{\pi}{4}\right)\sin(2\pi f_c t)\right\}$$

$$= A\cdot\frac{2}{\sqrt{T}}\cos\left(2\pi f_c t + \frac{\pi}{4}\right)$$

waveform 2

Similarly, $-A p_1(t) + A p_2(t)$

$$= A\cdot\frac{2}{\sqrt{T}}\cos\left(2\pi f_c t + \frac{5\pi}{4}\right)$$

$$-AP_1(t) - AP_2(t)$$

$$= \frac{2A}{\sqrt{T}} \cdot \cos\left(2\pi f_c t + \frac{3\pi}{4}\right)$$

$$x(t) = \begin{cases} \frac{2A}{\sqrt{T}} \cos\left(2\pi f_c t - \frac{\pi}{4}\right) \\ \frac{2A}{\sqrt{T}} \cos\left(2\pi f_c t + \frac{\pi}{4}\right) \\ \frac{2A}{\sqrt{T}} \cos\left(2\pi f_c t + \frac{3\pi}{4}\right) \\ \frac{2A}{\sqrt{T}} \cos\left(2\pi f_c t + \frac{5\pi}{4}\right) \end{cases}$$

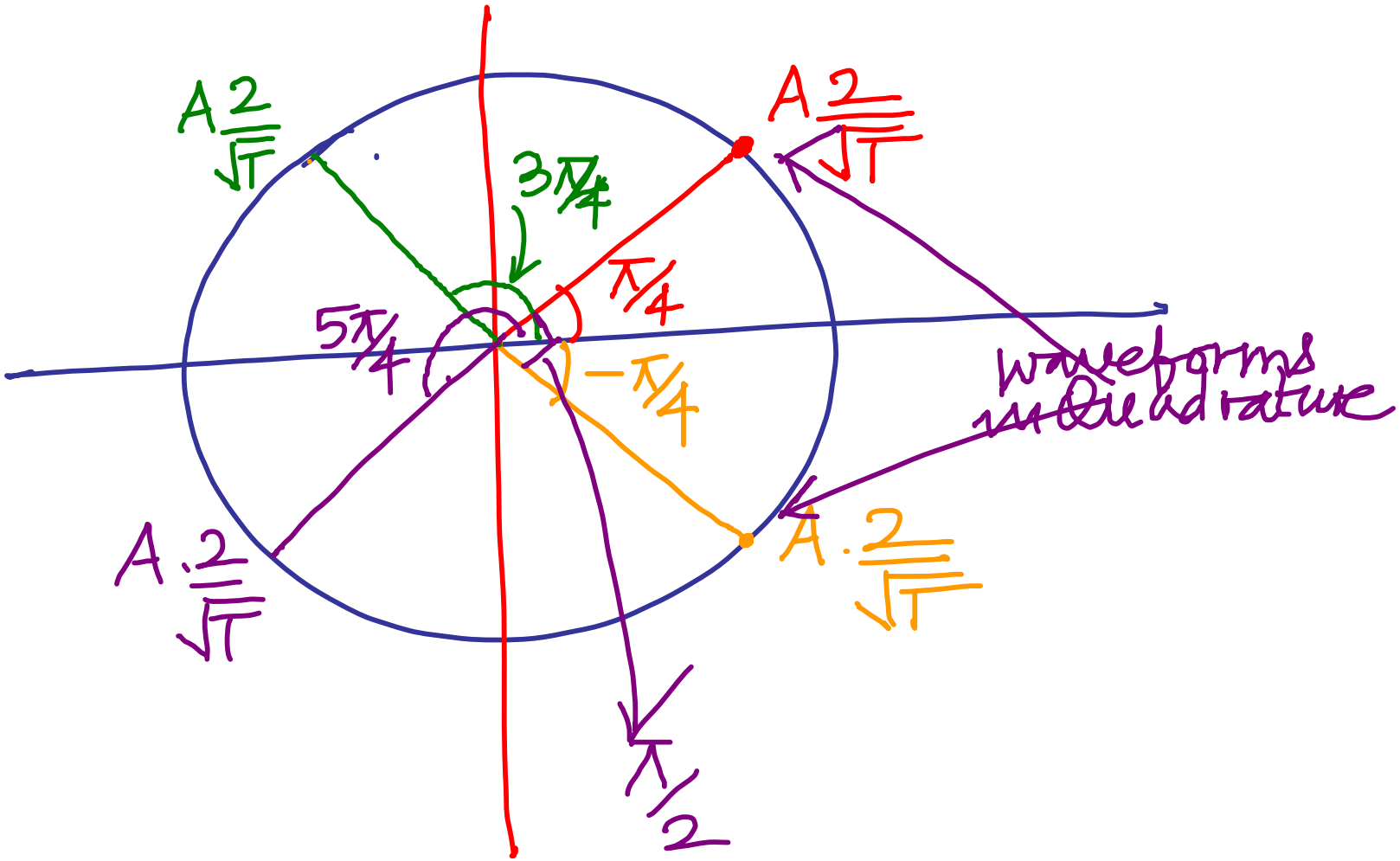
$\pi/2$ $\pi/2$ $\pi/2$ $\pi/2$

Phase difference between different waveforms $= \frac{\pi}{2}$

$= 90^{\circ}$.

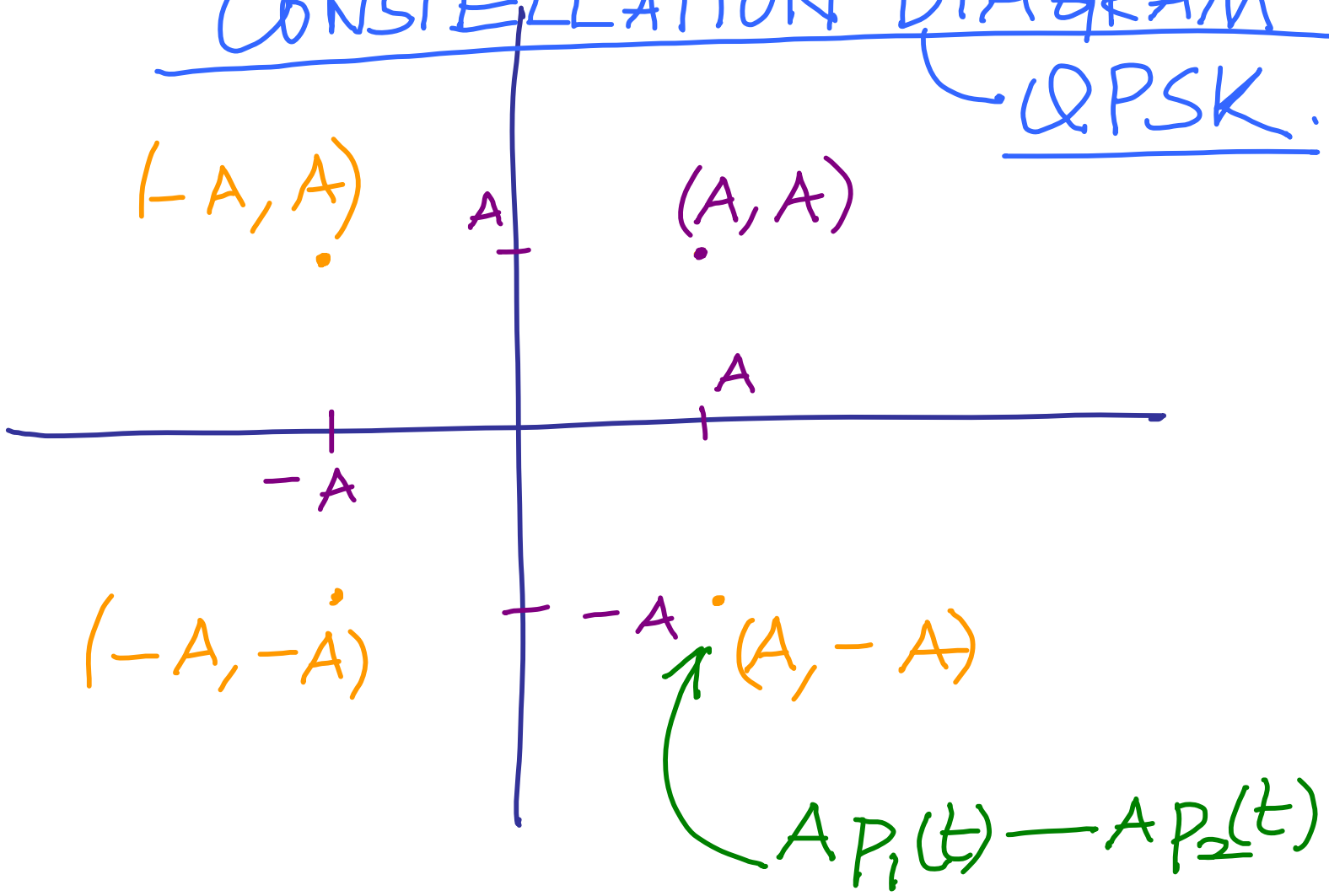
Quadrature

Therefore, the modulation scheme is termed as Quadrature Phase Shift Keying (QPSK).


A 2/√T
A 2/√T
3π/4
π/4
5π/4
−π/4
waveforms in Quadrature
A 2/√T
A 2/√T
π/2

CONSTELLATION DIAGRAM

QPSK.



QPSK
Receiver for QPSK
Matched Filter?