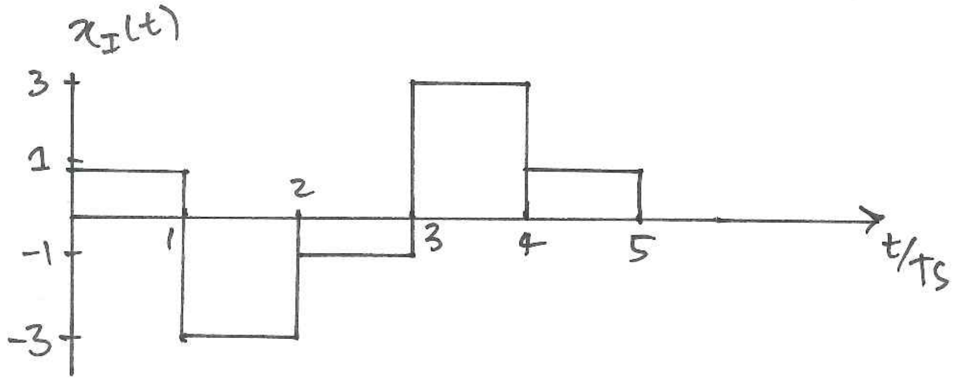
11.1

(a) baseband signal $x_I(t)$



(b) Homodyne Receiver, phase error $\phi_{err}(t) = -67.5^\circ$

$A=2$, Inphase and Quadrature components ?

$$U_I(t) = \frac{x_I(t)}{2} \cdot A \cdot \cos(\phi_{err}(t))$$

$$\boxed{U_I(t) = .3826} \qquad 0 \le t \le T_s$$

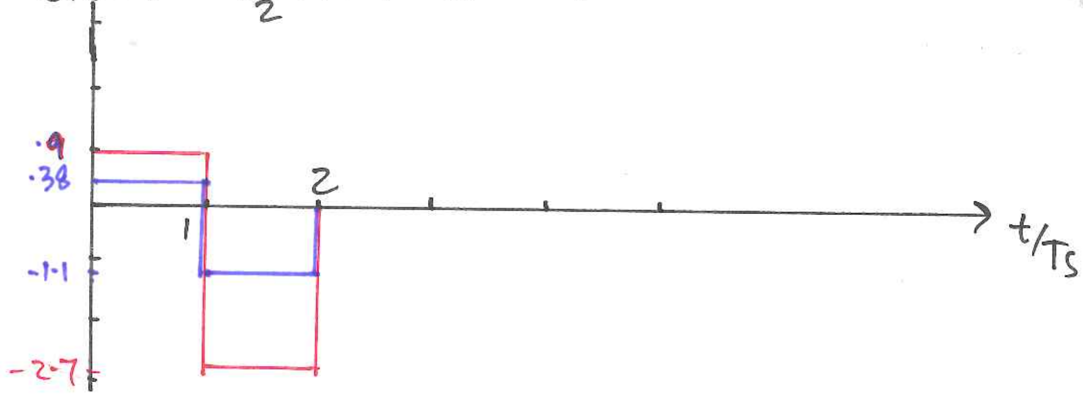
$$U_Q(t) = -\frac{x_I(t)}{2} \cdot A \cdot \sin(\phi_{err}(t))$$

$$\boxed{U_Q(t) = .9238} \qquad 0 \le t \le T_s$$

Similarly we can compute $U_I(t)$ and $U_Q(t)$ for $T_s \le t \le 2T_s$.

$$U_I(t) = -\frac{3}{2} \cdot A \cos(-67.5) = -3 \times (.3826) = -1.14$$

$$U_Q(t) = \frac{3}{2} \cdot A \sin(-67.5) = -2.7714$$



c) coherent reception

$\Rightarrow \hat{U}_I(t) = U_I(t) \cdot \cos(\phi_{err}(t)) - U_Q(t) \cdot \sin(\phi_{err}(t))$

$= \frac{x_I(t)}{2} A = x_I(t)$

(i) For $0 \le t \le T_s$

$\Rightarrow U_I(t) \cos(\phi_{err}(t))$

$0 \le t \le T_s$

$= .3826 \times .3826$

$= .144$

$U_Q(t) \sin(\phi_{err}(t))$

$= .9283 \times (-.9283)$

$= -.85$

and $\hat{U}_I(t) = x_I(t) \approx .144 - (-.85) = .9940 \approx 1$

(ii) For $T_s \le t \le 2T_s$

$U_I(t) \cos(\phi_{err}(t))$

$= -1.14 \times .3826$

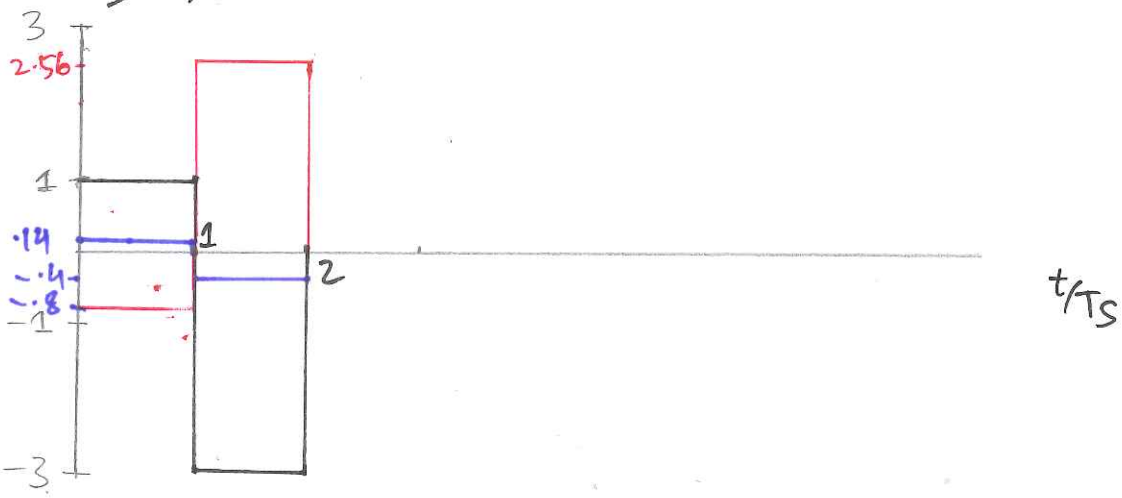
$= -.4362$

$U_Q(t) \sin(\phi_{err}(t))$

$= (-2.7714)(-.9238)$

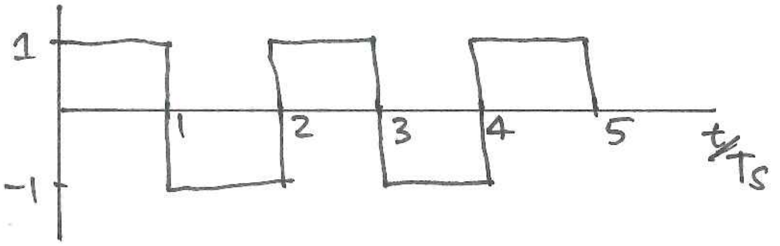
$= 2.5602$

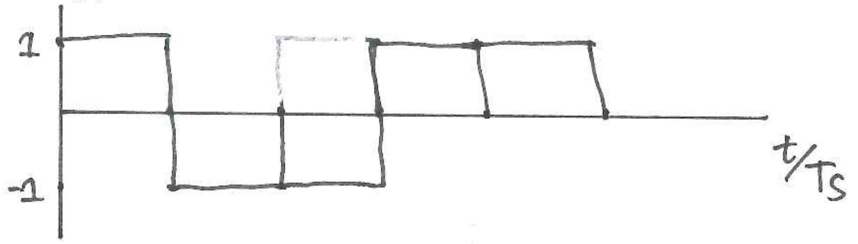
$\hat{U}_I(t) = -.4362 - 2.5602 = -2.99 \approx -3 = x_I(t)$



11.2

(a)





(b) $U_I(t) = \frac{Y_I(t)}{2} A \cos(\phi_{err}(t)) + \frac{Y_Q(t)}{2} A \sin(\phi_{err}(t))$

when channel is perfect $(h(t) = 1) \times \delta(t))$ and $w(t) = 0$ (No Noise) then

$$Y_I(t) = x_I(t)$$

hence
$$\begin{cases} U_I(t) = \frac{x_I(t)}{2} A \cos(\phi_{err}(t)) + \frac{x_Q(t)}{2} A \sin(\phi_{err}(t)) \\ U_Q(t) = \frac{x_Q(t)}{2} A \cos(\phi_{err}(t)) - \frac{x_I(t)}{2} A \sin(\phi_{err}(t)) \end{cases}$$

(i) $0 \le t \le T_s$

$U_I(t) = \frac{1}{2} . A . \cos(-67.5^\circ) + \frac{1}{2} . A \sin(-67.5^\circ)$

$U_I(t) = -.5412$

$U_Q(t) = 1.3066$

(ii) $T_s \le t \le 2T_s$

$U_I(t) = .5412$

$U_Q(t) = -1.3066$

(c) Not possible to see the original data in $U_I(t)$, $U_Q(t)$ (Original data being $x_I(t)$ and $x_Q(t)$).

Compare $U_I(t)$ with $x_I(t)$. $U_I(t)$ is different from $x_I(t)$ due to cross talk.

11.3

$$y(t) = x_I(t)\cos(2\pi f_c t) - x_Q(t)\sin(2\pi f_c t)$$ at the input of homodyne receiver

(a) $$\hat{U}_I(t) = U_I(t)\cos(\phi_{err}(t)) - U_Q(t)\sin(\phi_{err}(t))$$

$$U_I(t)\cos(\phi_{err}(t)) = \frac{x_I(t)}{2}.A.\cos^2(\phi_{err}(t) + \frac{x_Q(t)}{2}.A\sin(\phi_{err}(t))\cos(\phi_{err}$$

$$U_Q(t)\sin(\phi_{err}(t)) = \frac{x_Q(t)}{2}.A.\cos(\phi_{err}(t))\sin(\phi_{err}(t)) - \frac{x_I(t)}{2}.A.\sin^2(\phi_{err}(t))$$

hence

$$\hat{U}_I(t) = \frac{x_I(t)}{2}.A(\cos^2(\phi_{err}(t)) + \sin^2(\phi_{err}(t)))$$

$$\hat{U}_I(t) = \frac{x_I(t)}{2}.A$$

By choosing $A=2$, $x_I(t)$ can be fully recovered despite of phase error.

(b) By choosing

$$\hat{U}_Q(t) = U_I(t)\sin(\phi_{err}(t)) + U_Q(t)\cos(\phi_{err}(t))$$

we can recover $x_Q(t)$ as well.

11.4 $\tilde{U}(t) = \frac{\tilde{x}(t)}{2} A \cdot e^{-j\phi_{err}(t)}$

Sol

Since $e^{j\theta} = \cos\theta + j\sin\theta$.

$$\tilde{U}(t) = \frac{1}{2}\left(x_I(t) + j\, x_Q(t)\right) \cdot A \cdot \left(\cos(\phi_{err}(t)) - j\sin\phi_{err}(t)\right)$$

$$= \frac{A}{2}\Big[x_I(t)\cos(\phi_{err}(t)) + x_Q(t)\sin\phi_{err}(t) + j\left(x_Q(t)\cos(\phi_{err}(t)) - x_I(t)\sin(\phi_{err}(t))\right)\Big]$$

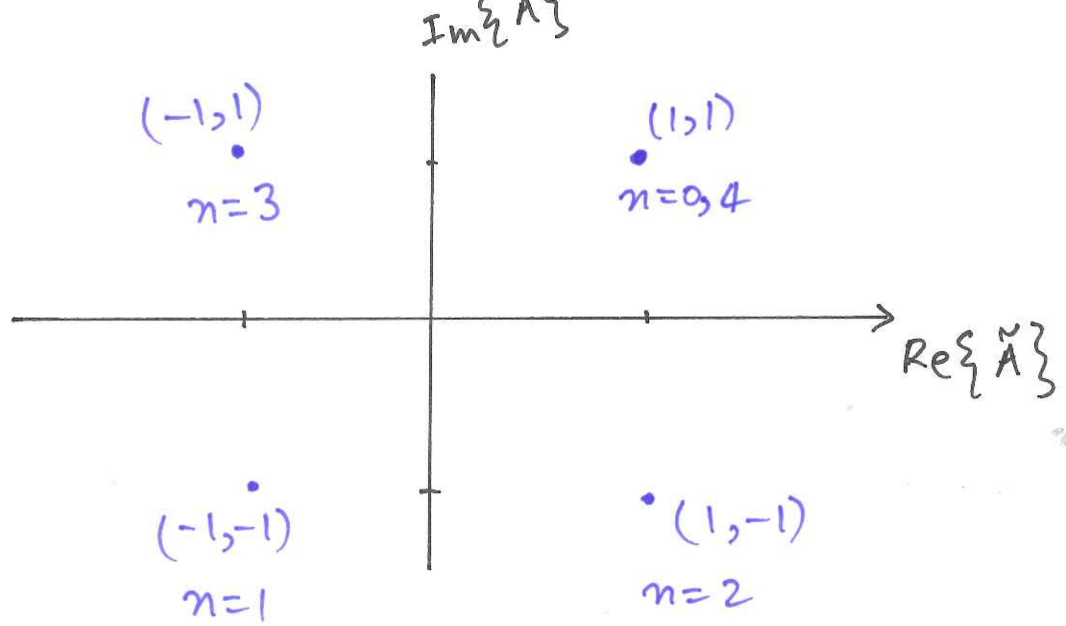
we can see that

$U_I(t) = Re\{\tilde{U}(t)\}$ and $U_Q(t) = Im\{\tilde{U}(t)\}$

11.5 (a) complex baseband notation.

$\tilde{A}_{m[n]} = (1+j), (-1-j), (1-j), (-1+j), (1+j)$

(b)



(c)

$$\tilde{y}_{m[n]} = \tilde{c}\left(\tilde{A}_{m[n]}\tilde{\alpha}\, e^{-j\phi_{err,n}} \frac{A E_g}{2} + 0\right) \quad \text{—} ①$$

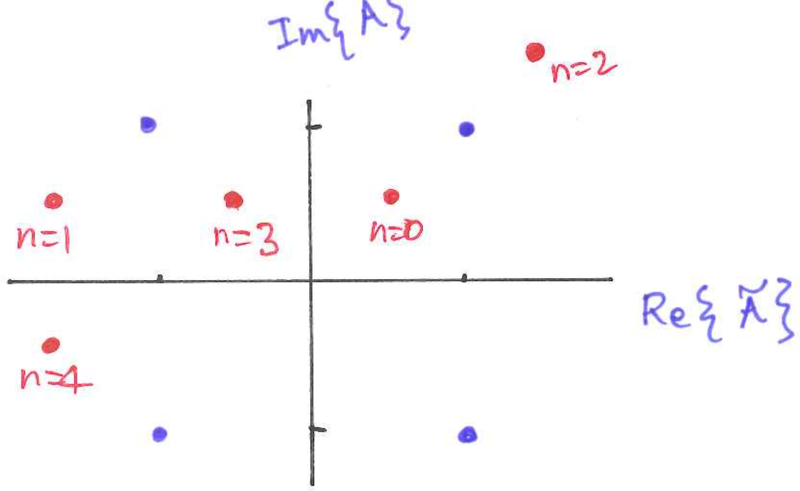
$$(\text{since } \tilde{N}_n = 0)$$

If $\tilde{y}_{m[n]} = \tilde{A}_{m[n]}$ then Eq 1 becomes

$$\tilde{c}\,(.001\, e^{-j\phi_\alpha}) \cdot e^{-j\phi_{err}} \frac{A E_g}{2} = 1$$

$$\boxed{\tilde{c} = 1000 \cdot e^{j(\phi_\alpha + \phi_{err})} \cdot \frac{2}{A E_g}}$$

(d)



Decision of Min. Euclidean distance receiver will be

$\tilde{A}_{m[n]} = (1+j),\ (-1+j),\ (1+j),\ (-1+j),\ (-1-j)$

Since in Prob 11.2 we have defined the mapping $0 \rightarrow -1$ and $1 \rightarrow 1$, ~~above~~ the bit sequence is

$\hat{b} = 1101110100$