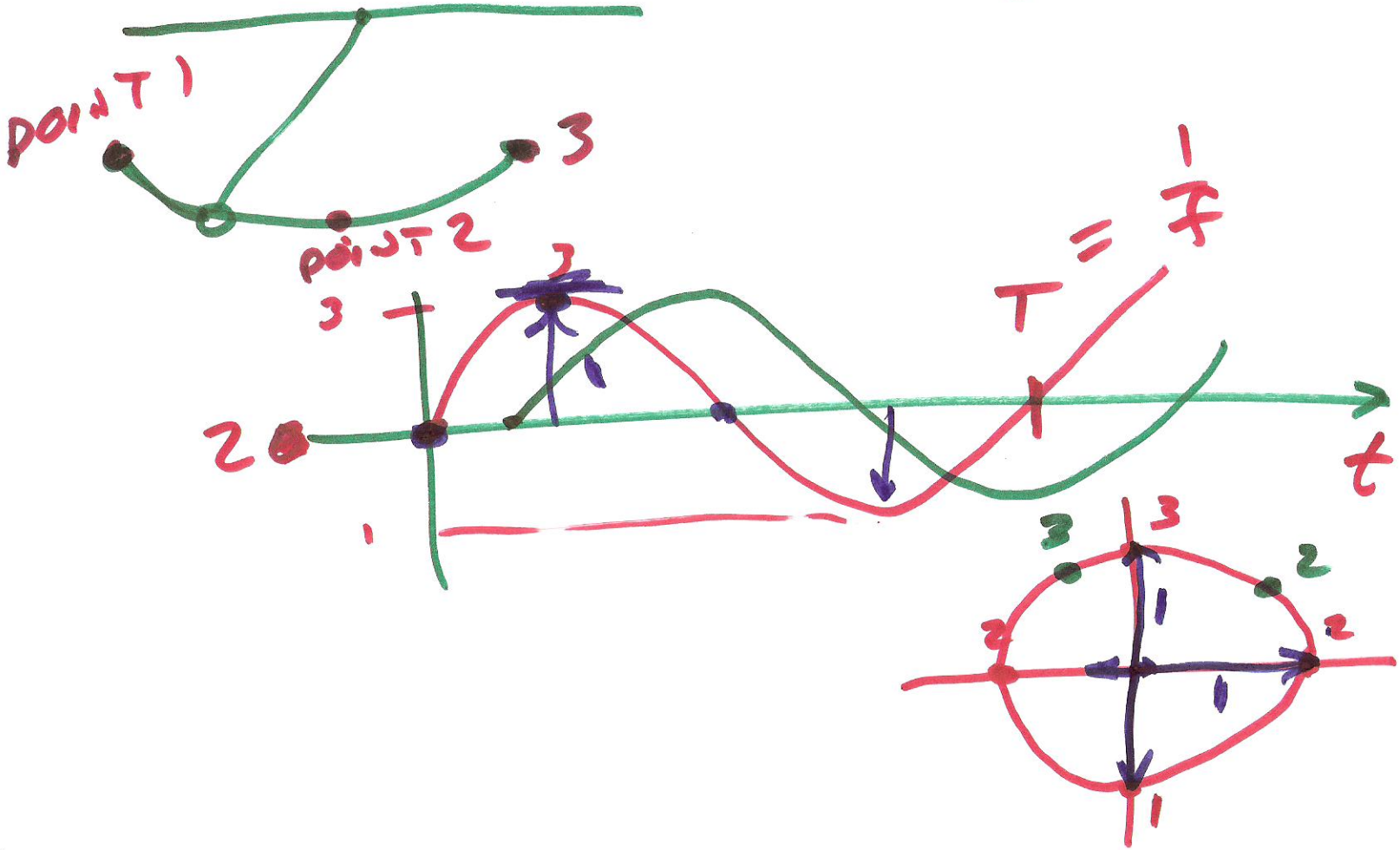
ECE 615 CMOS mixed-signal circuit Design

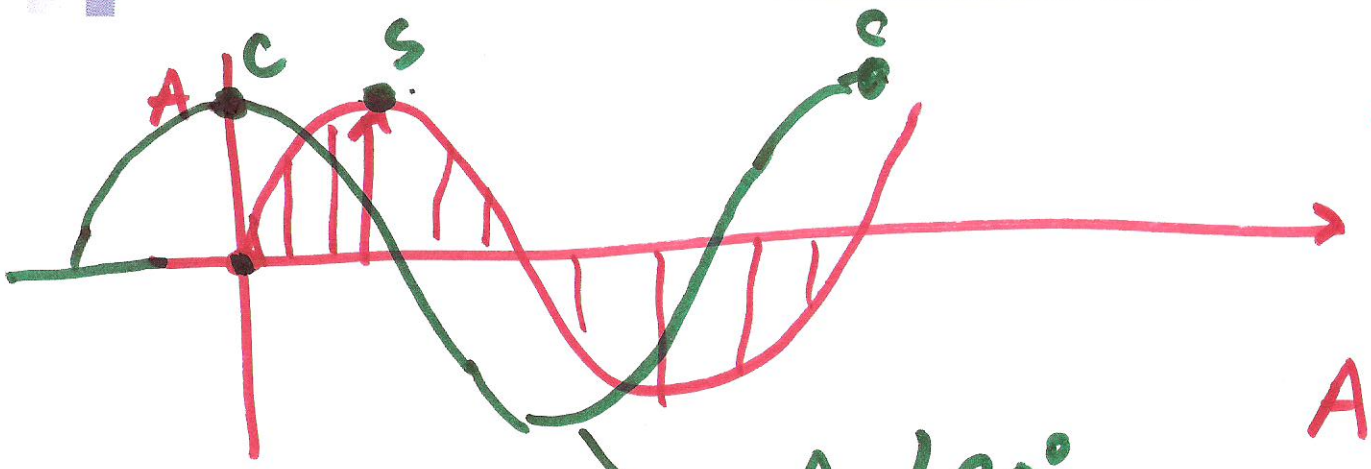
BOISE STATE UNIVERSITY

Lecture 1

Aug. 23, 2010




1)



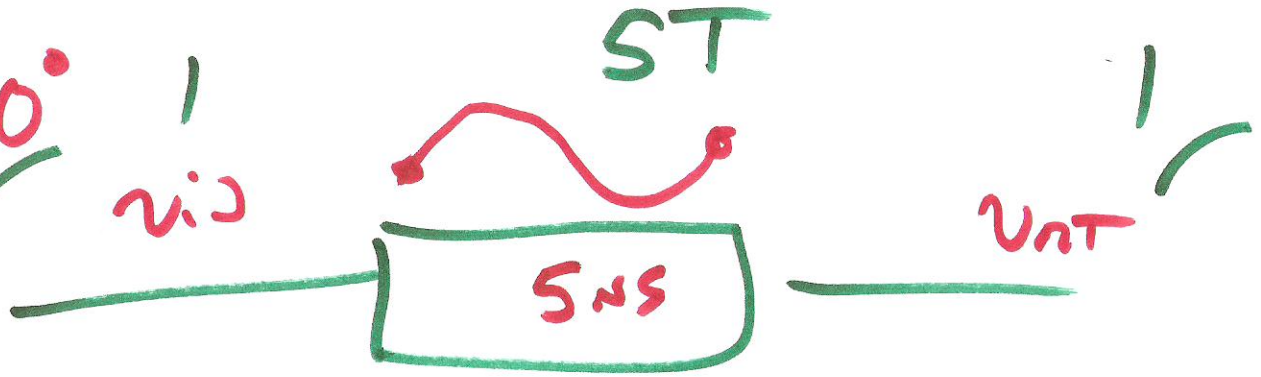

$\sin 2\pi \frac{t}{T}$

$A \angle 0°$

$A \angle 90°$

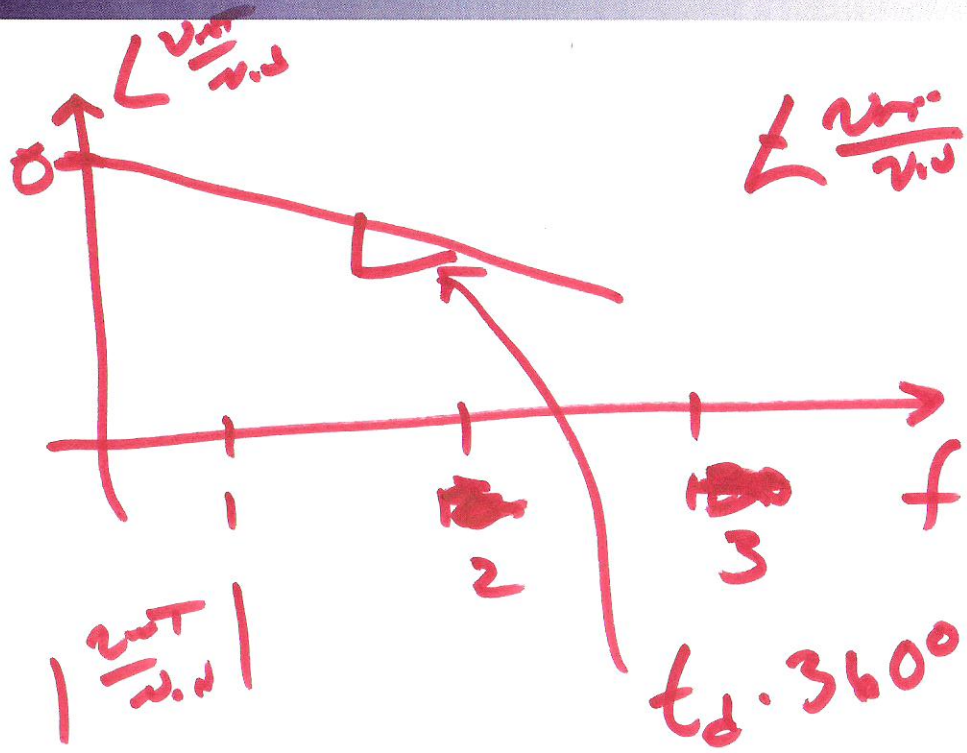
$\angle \frac{v_{out}}{v_{in}} \rightarrow$ neg

$\theta = \frac{t_d}{T} \cdot 360°$




$= t_d \cdot f \cdot 360°$

$\angle \frac{v_{out}}{v_{in}} = -\frac{S_N}{t_d} \cdot f \cdot 360°$



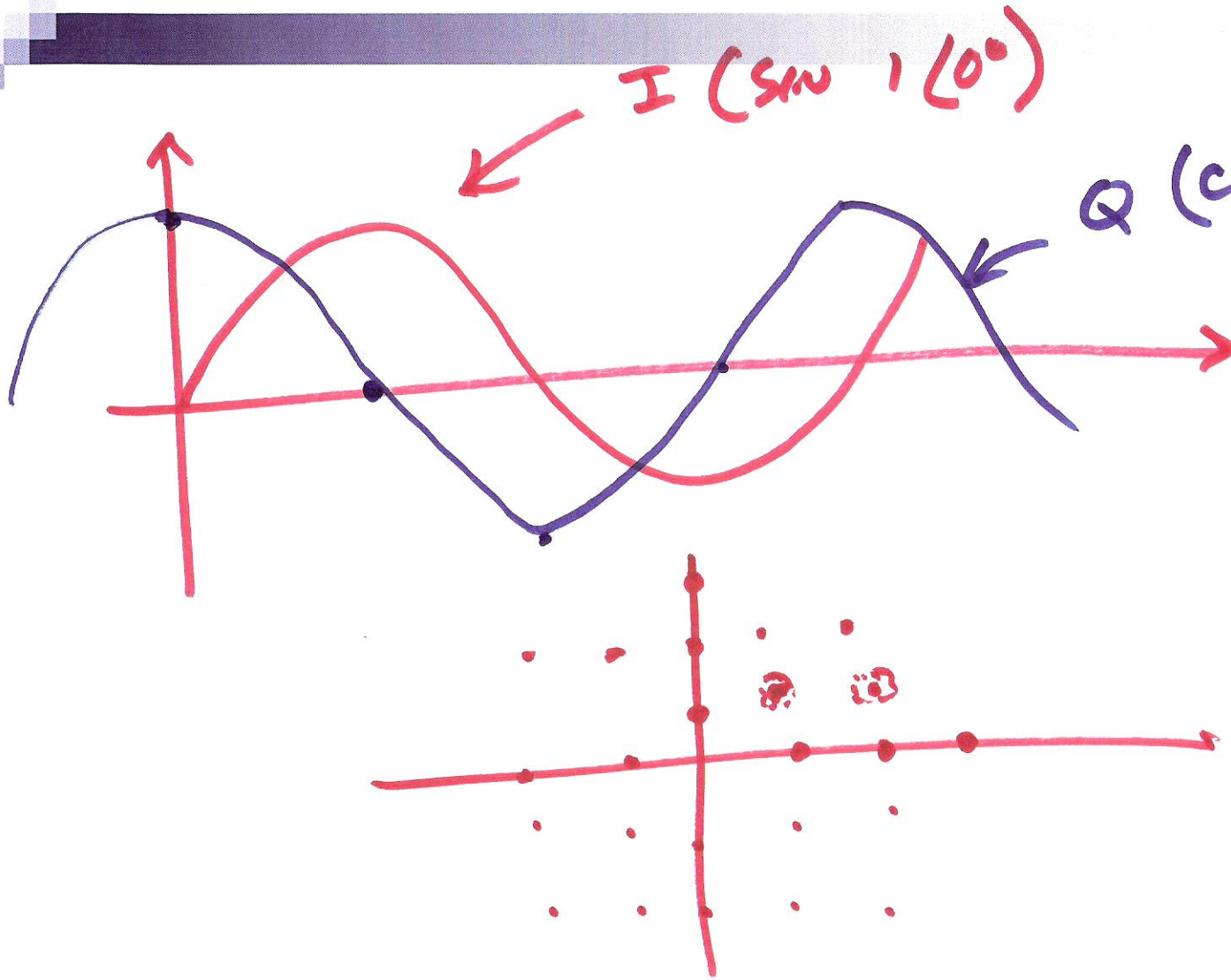

$$\angle \frac{Y(f)}{X(f)} = -t_d \cdot f \cdot 360°$$

$$= -\frac{t_d}{T} \cdot 360°$$

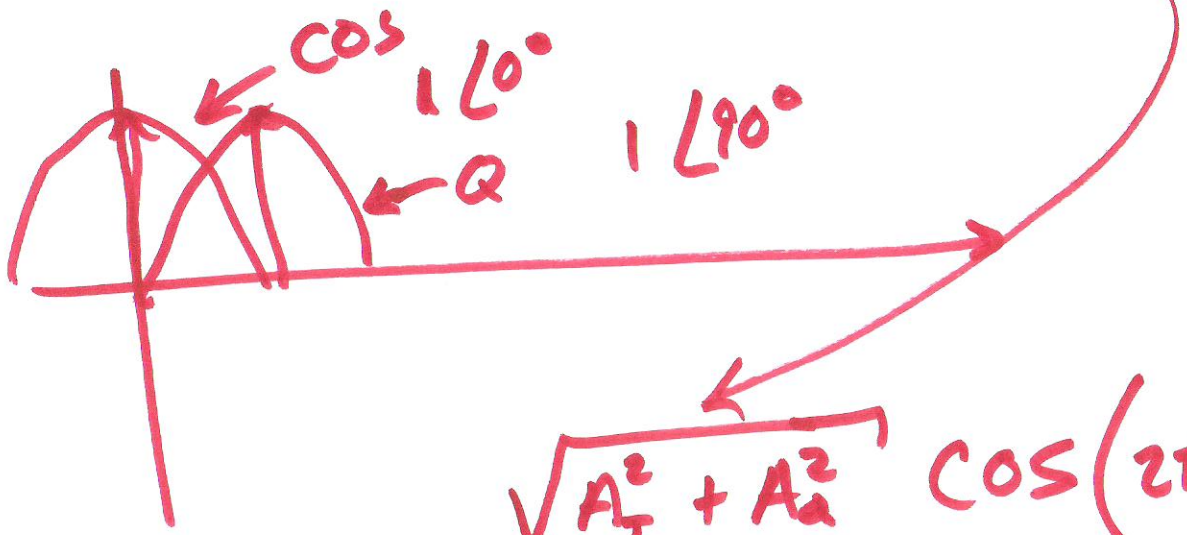

Constant $\left|\frac{Y(f)}{X(f)}\right|$

Linear phase $\angle$

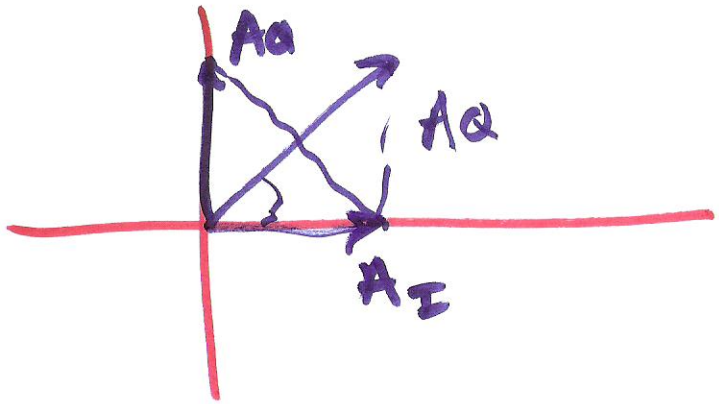
3)


I (sin 1∠0°)
Q (cos 1∠90°)

$$s_{IQ}(t) = A_I \cos 2\pi f_0 \cdot t + A_Q \sin 2\pi f_0 \cdot t$$

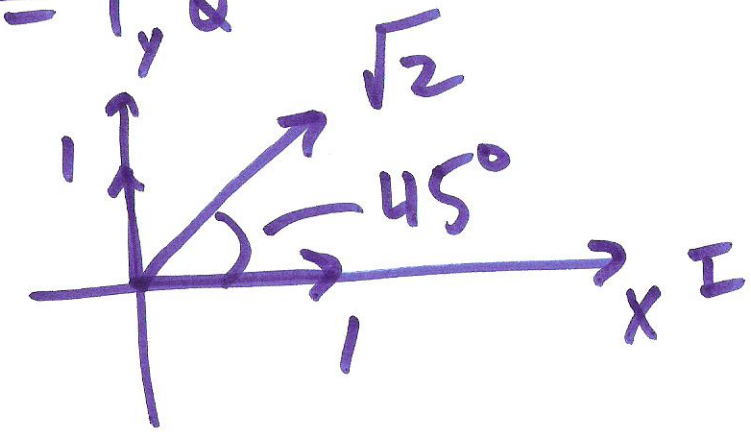



$$\sqrt{A_I^2 + A_Q^2} \cos\left(2\pi f_0 \cdot t + \tan^{-1} \frac{A_Q}{A_I}\right)$$

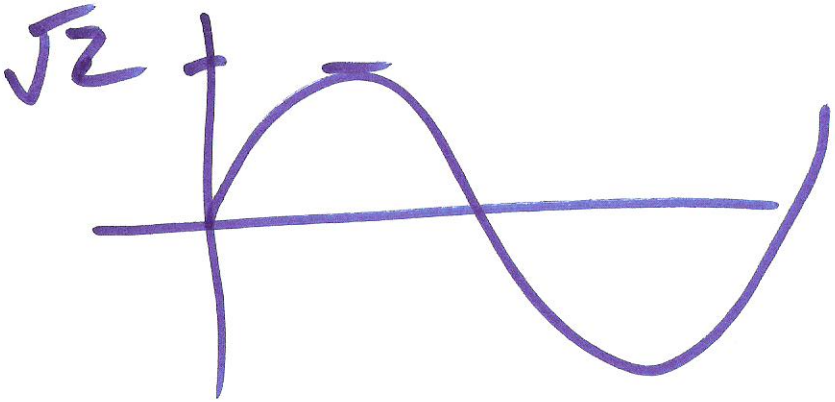



5)

$A_Q = A_I = 1, Q$




$\sqrt{2}\cos(2\pi f \cdot t + 45°)$



$$e^{x} = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \frac{x^4}{4!} + \cdots$$

$$\cos x = 1 - \frac{x^2}{2!} + \frac{x^4}{4!} - \frac{x^6}{6!} + \cdots$$

$$\sin x = x - \frac{x^3}{3!} + \frac{x^5}{5!} - \frac{x^7}{7!} + \cdots$$

$j$ = $i$ = $\sqrt{-1}$

$$e^{jx} = 1 + jx + \frac{(jx)^2}{2!} + \frac{(jx)^3}{3!} + \frac{(jx)^4}{4!} + \frac{(jx)^5}{5!}$$

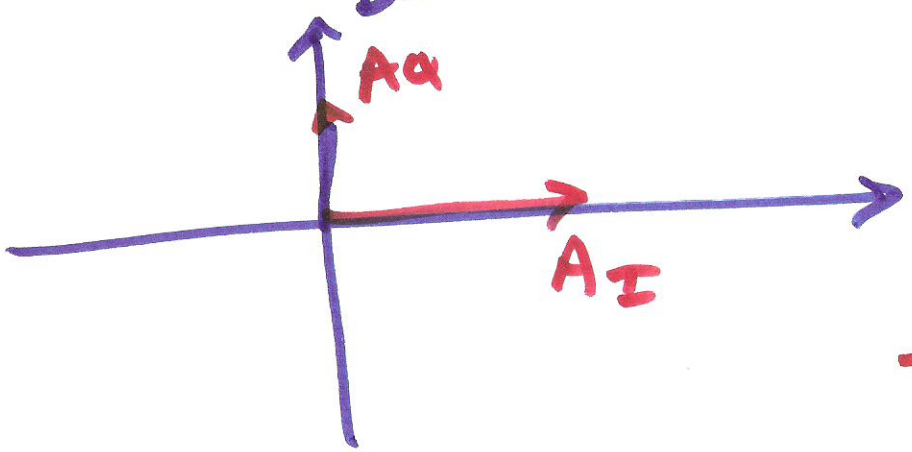
$$= 1 + jx - \frac{x^2}{2!} - j\frac{x^3}{3!} + \frac{x^4}{4!} + j\frac{x^5}{5!}$$

$$= \cos x + j \sin x$$

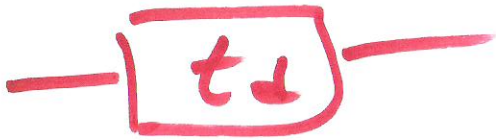
7)

$$e^{jk} = A\cos k + j \cdot A\sin k$$

$A\cos k$: I, In-phase — $A\sin k$: Q, Quadrature

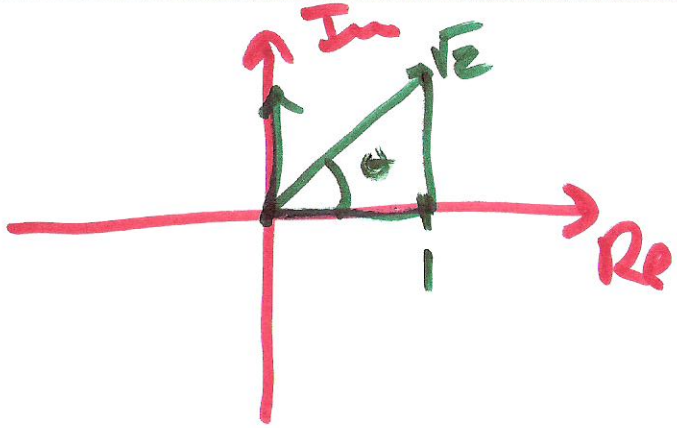



$$\varphi = \frac{t_d}{T} \cdot 360$$




$$\angle\varphi = t_d \cdot f \cdot 360$$

$$\angle A_N^{-1}$$




$$A_I \cos 2\pi f t + A_Q \sin 2\pi f t$$

$$e^{jk} = \underbrace{\cos k}_{Re} + j\underbrace{\sin k}_{Im}$$

$$\theta = \tan^{-1}\frac{Im}{Re}$$

$$\theta = \tan^{-1}\frac{\sin k}{\cos k} = k$$

$$k = 2\pi f \cdot t$$


$\theta = -2\pi \cdot \frac{t_d}{T} = 2\pi \cdot t_d \cdot f$

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

$= \sqrt{\cos^2\theta + \sin^2\theta}$

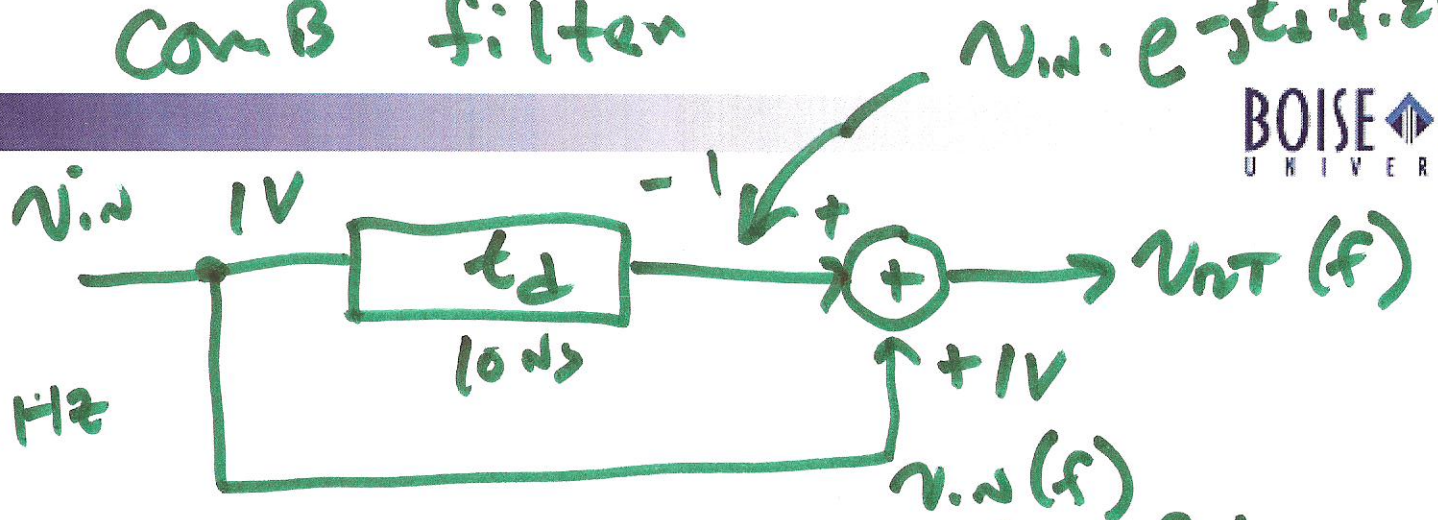
$\angle \tan^{-1} \frac{\sin\theta}{\cos\theta}$

$= \sqrt{1}\angle\theta$

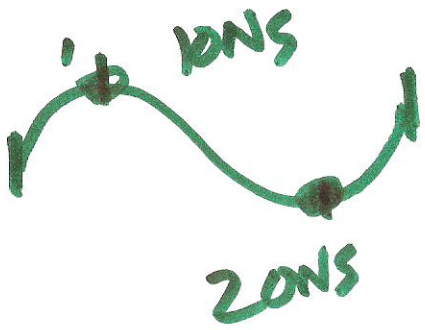
$= 1\angle\theta$

$e^{-j2\pi \cdot \frac{t_d}{T}} = e^{j\theta}$

Comb filter




$f = 50\,MHz$




$$v_{nT} = v_{in} + v_{in} \cdot e^{-j2\pi f t}$$

$$\frac{v_{nT}}{v_{in}} = 1 + e^{-j2\pi f t}$$

Re + Im

$$= \underbrace{1 + \cos(-2\pi f t)}_{Re} + j\sin(-2\pi f t)$$

11)

$$\left|\frac{v_{out}}{v_{in}}\right| = \sqrt{(1+\cos(2\pi f t))^2 + \sin^2(2\pi f T)}$$

$$\angle = \frac{\sin(-2\pi f t)}{1+\cos(-2\pi f t)}$$

$$1+\cos x = 2\cos^2\frac{x}{2}$$

$$\sin x = 2\sin\frac{x}{2}\cos\frac{x}{2}$$

$$\left|\frac{v_{out}}{v_{in}}\right| = 2\left|\cos \pi f \cdot t_d\right|$$

$$\angle\frac{v_{out}}{v_{in}} = \pi(-t_d)\cdot f$$

$$f < \frac{1}{2t_d}$$