Basics 1

2015/03/06

Michael Tsai

Harmonic Signals and Exponentials

$y = \cos(\omega_1 t)$

$= \cos(2\pi f_1 t)$ → ω: angular frequency 單位時間內轉多少 rad

$\omega_1 = 2\pi$ $f_1 = 1$

1 Hz

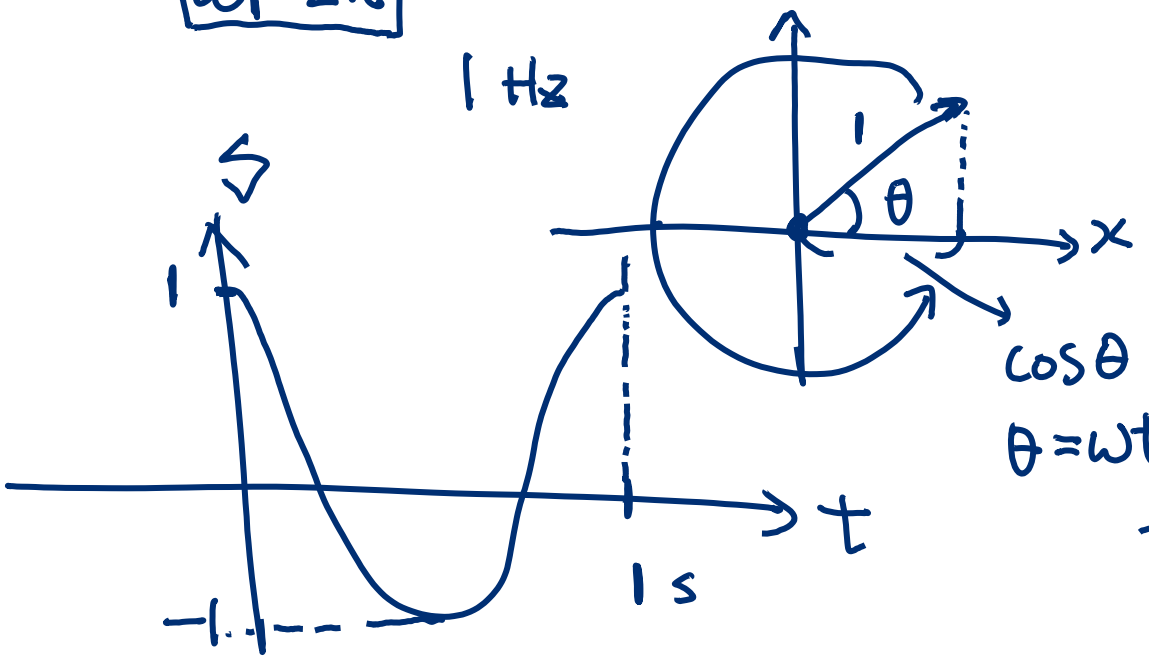
f: frequency 單位時間轉多少圈 ($\rightarrow 2\pi$)

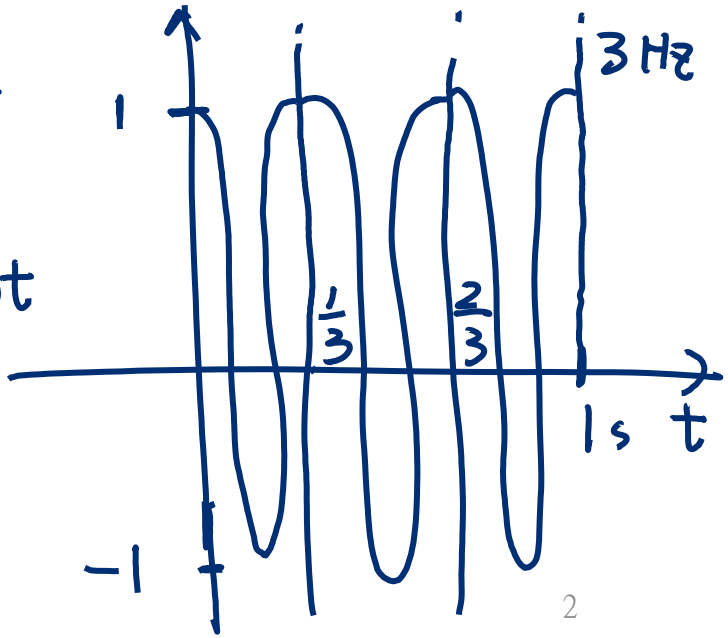
$\cos(2\pi f t)$

ω

$\omega_2 = 6\pi$ $2\pi f_2$ $f_2 = 3$

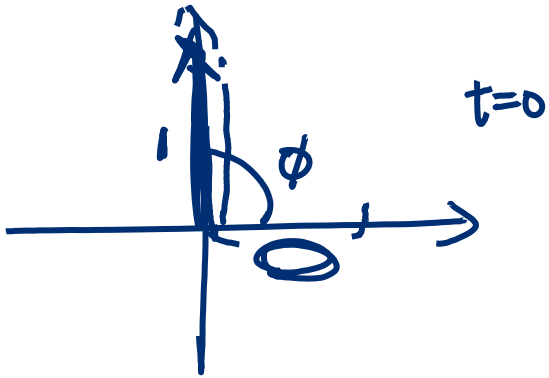
$y = \cos(\omega_2 t)$



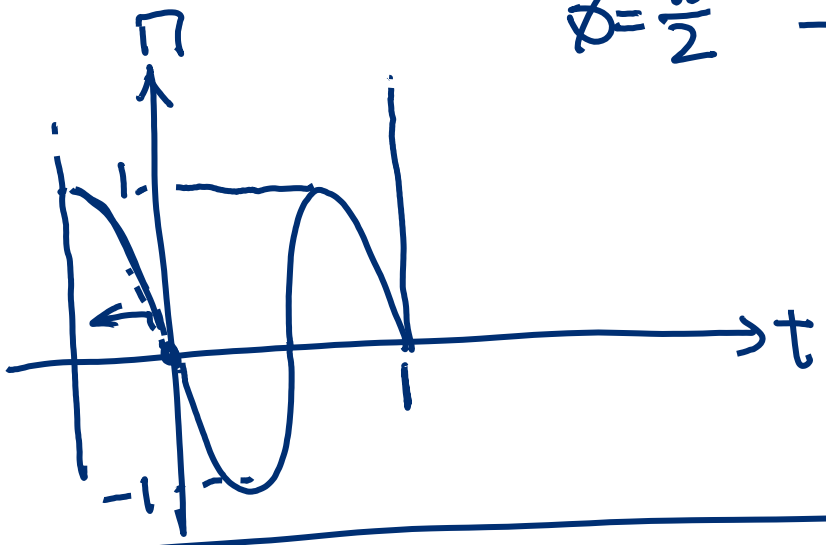


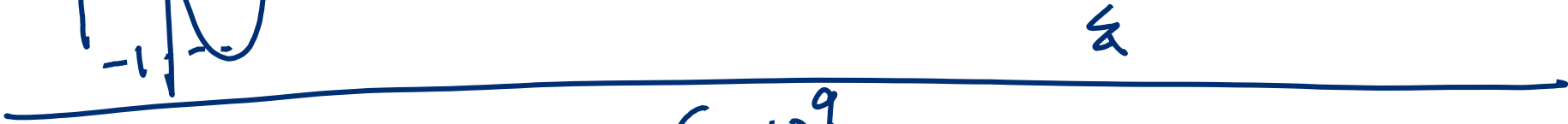
$f=1$

$\pi = \cos(2\pi f t + \phi)$



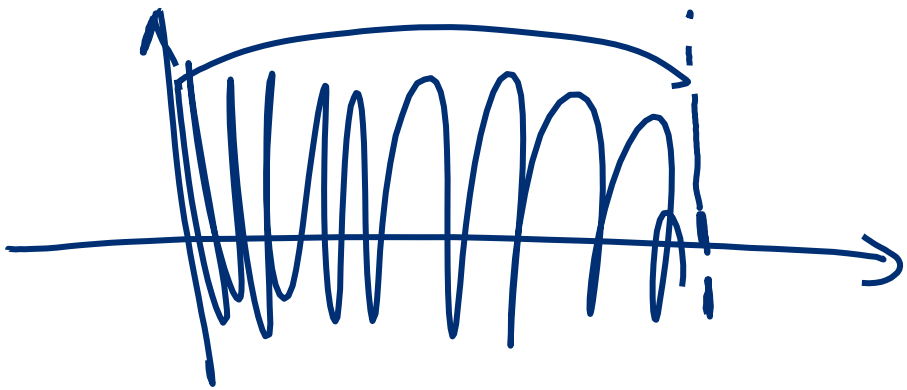
$\phi = \frac{\pi}{2}$





f_c 2.4 GHz $G = 10^9$ $\cos(2\pi f_c + \theta)$

2400,000,000 Hz



Complex Numbers

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

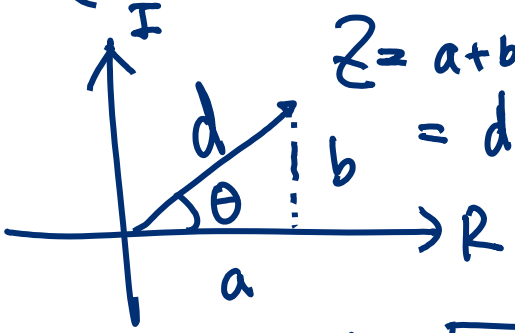
$z = a + bi$

$z^* = a - bi$

$z_1 \quad z_2$

$(a+bi) + (c+di)$

$= (a+c) + (b+d)i$



$z = a + bi$

$= de^{i\theta}$

$d = \sqrt{a^2 + b^2}$

$\theta = \tan^{-1}\left(\frac{b}{a}\right)$

$z = de^{i\theta}$

$= d\cos\theta + di\sin\theta$

$a = d\cos\theta$

$b = d\sin\theta$

$z_1 = d_1 e^{i\theta_1} \quad z_2 = d_2 e^{i\theta_2}$

$z_1 \cdot z_2 = d_1 d_2 e^{i\theta_1} e^{i\theta_2}$

$= d_1 d_2 e^{i(\theta_1+\theta_2)}$

$e^{i(\omega t \pm \phi)} = \cos(\omega t \pm \phi) + i\sin(\omega t \pm \phi)$

$= e^{i\omega t} e^{i\phi}$

$= \cos(\omega t)\cos\phi - \sin(\omega t)\sin\phi$

$+ i\sin(\omega t)\cos\phi + i\cos(\omega t)\sin\phi$

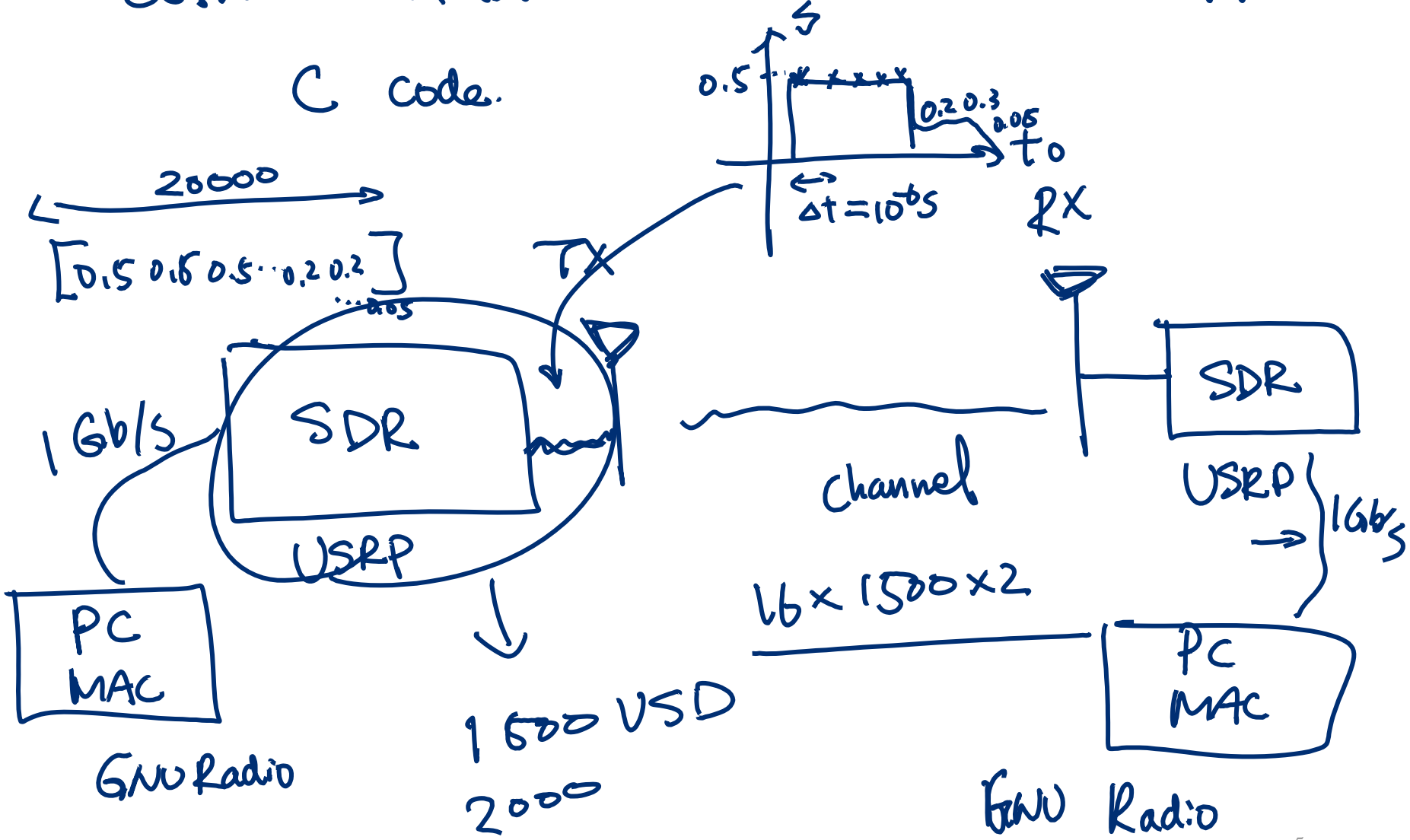
$= [\cos(\omega t) + i\sin(\omega t)] \cdot [\cos\phi + i\sin\phi]$

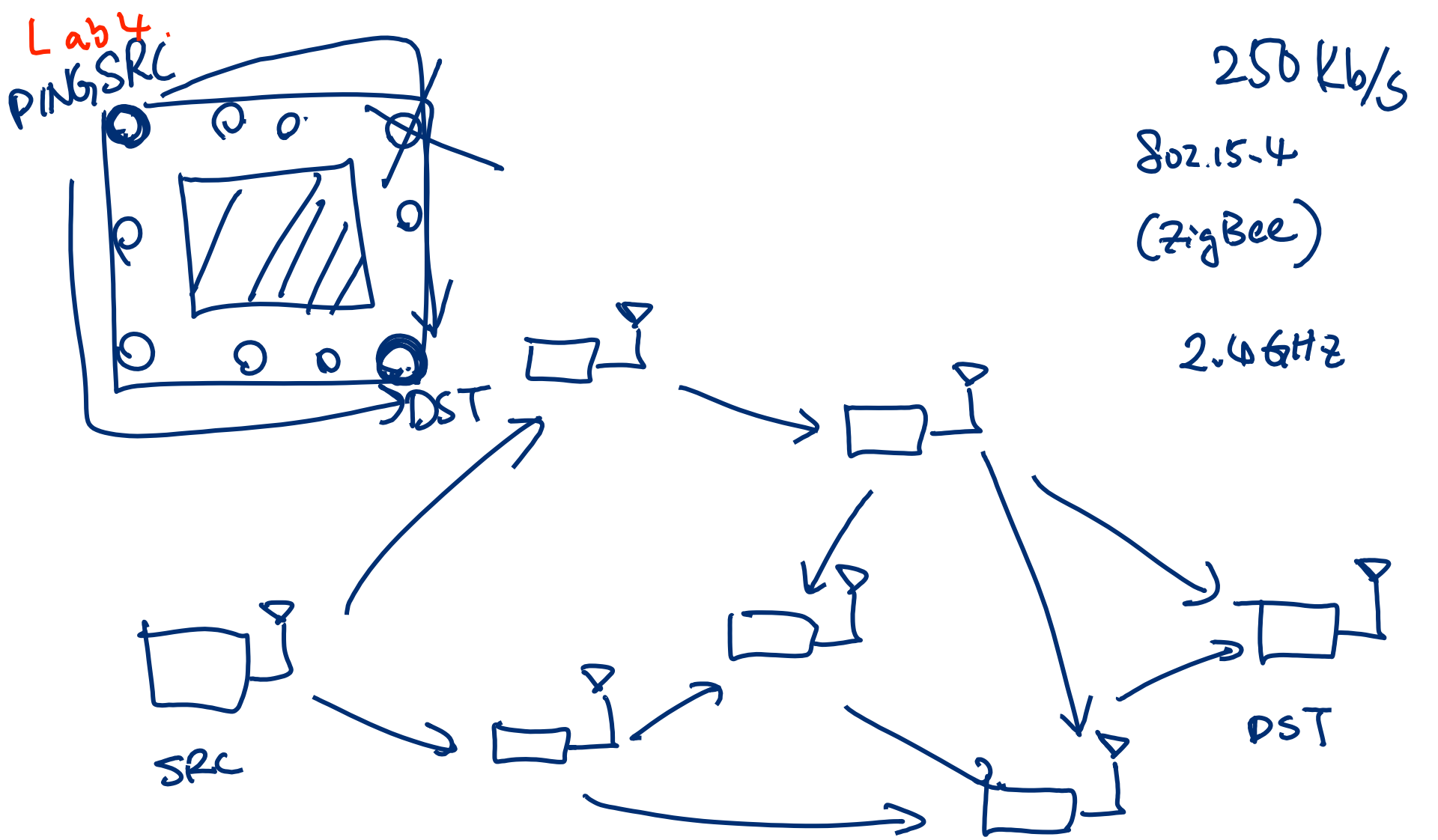
$=$

Lab 3.

Software Defined Radio + WiFi + OFDM

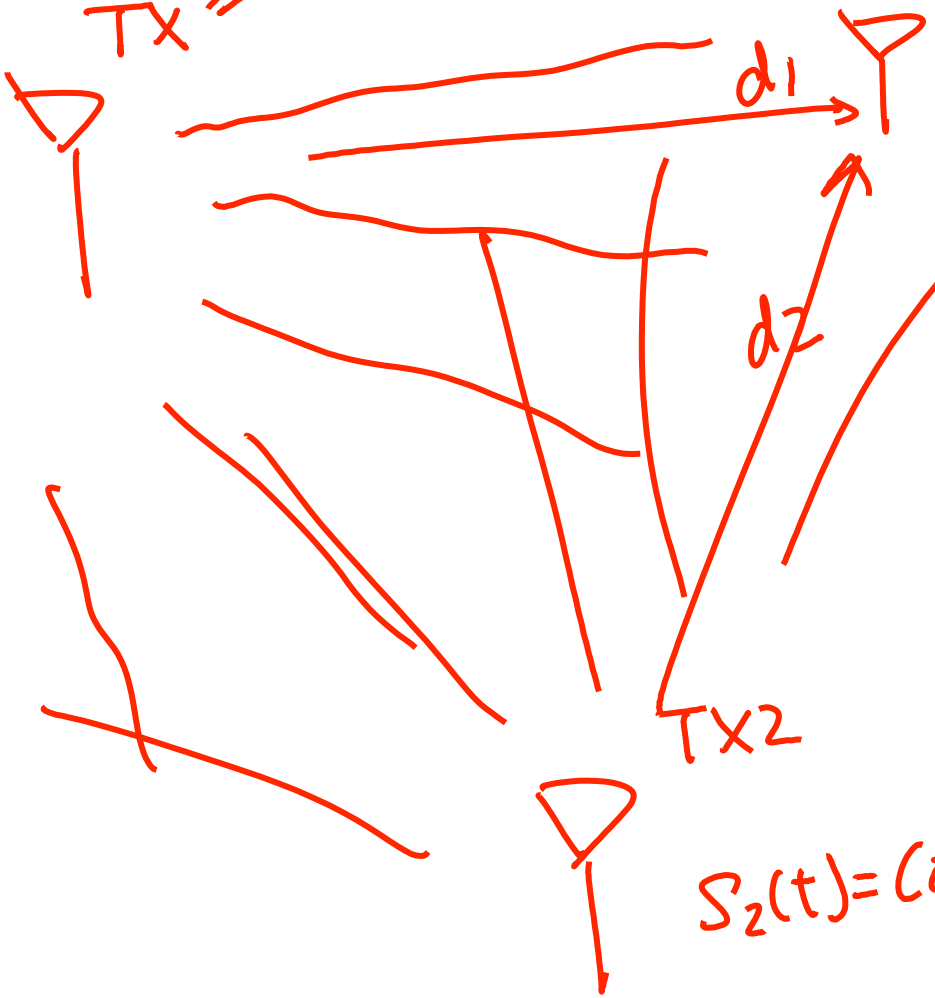
C code.

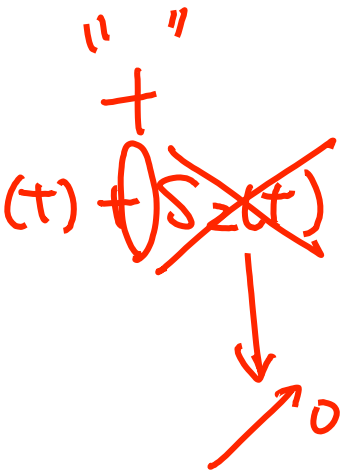


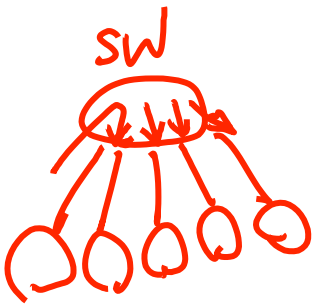

Lab4.
PING SRC
DST
250 Kb/s
802.15.4
(ZigBee)
2.4GHz
SRC
DST

Multiplexing $S(t) = \cos(\omega t + \phi)$

TX = Transmitter RX = Receiver



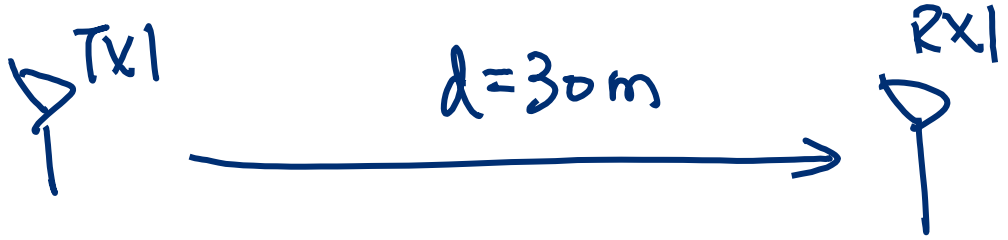




Wireless

$S_2(t) = \cos(\omega t + \phi)$ ⇒ Broadcast

"+"



① Propagation Delay

$C = 3 \times 10^8$ m/s

$\Delta t = \frac{d}{c} = \frac{10 \times 3}{3 \times 10^8}$

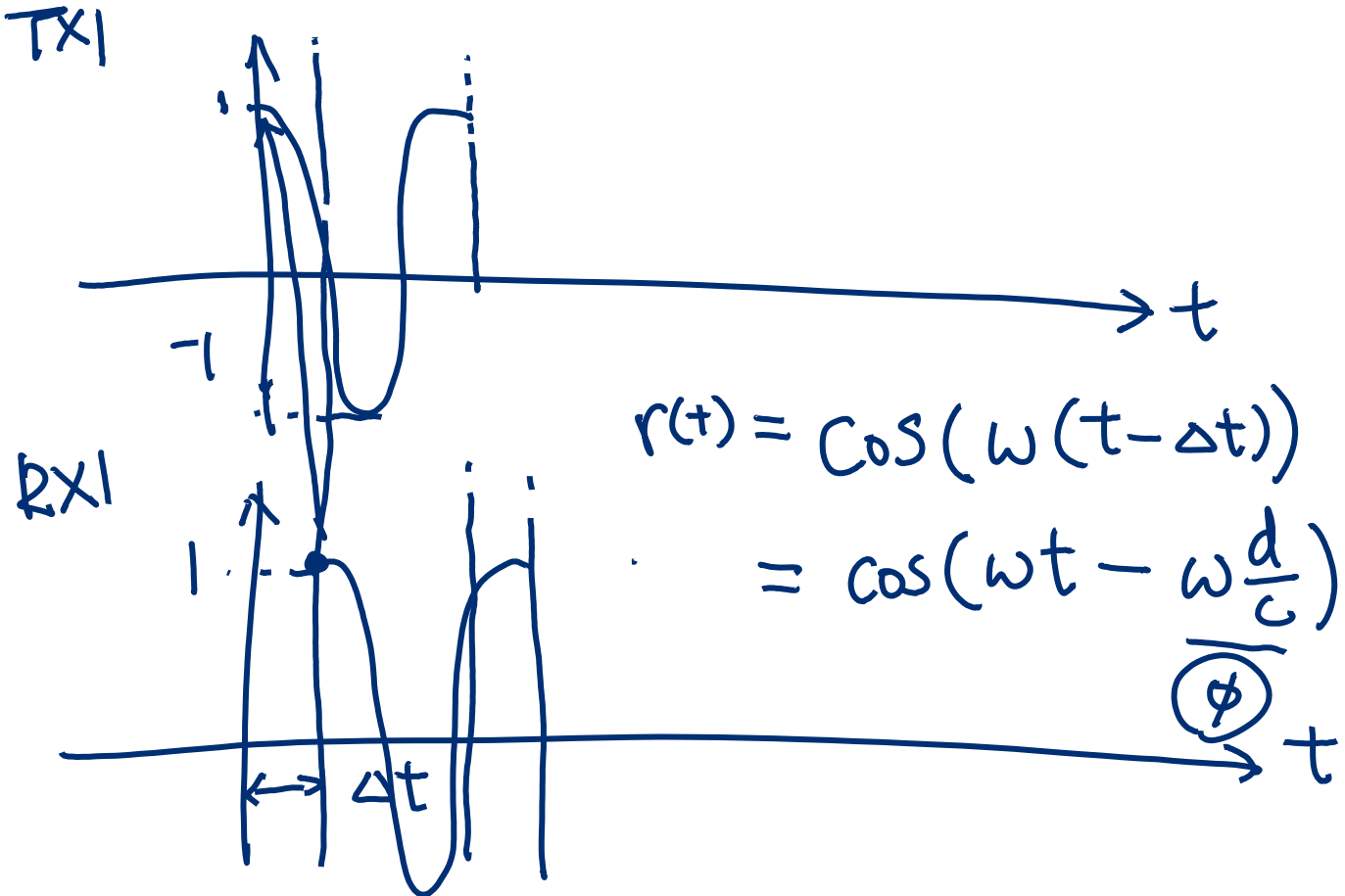
$= 10^{-7}$ s

$= 100$ ns

1 ns $= 10^{-9}$ s

$s_1(t) = \cos(\omega t)$

$r_1(t) = \cos(\omega t + \square)$



$r(t) = \cos(\omega(t - \Delta t))$

$= \cos(\omega t - \omega \frac{d}{c})$

ϕ

$$s(t) = A\cos(\omega t)$$

$$r(t) = \frac{A}{a}\cos(\omega t + \phi)$$

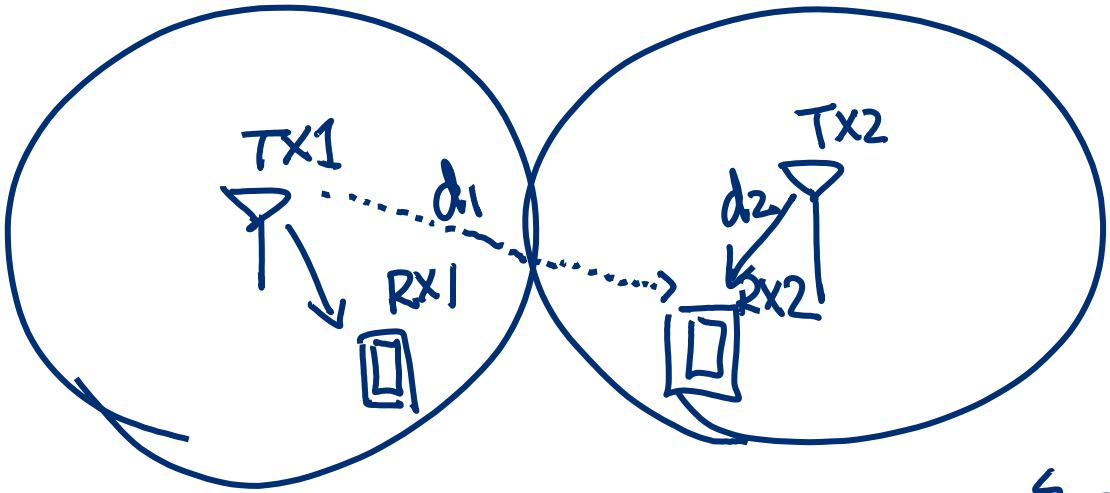
(3)

a: channel loss

$$a \propto d^{r}$$

1. Spatial Multiplexing (Directional)

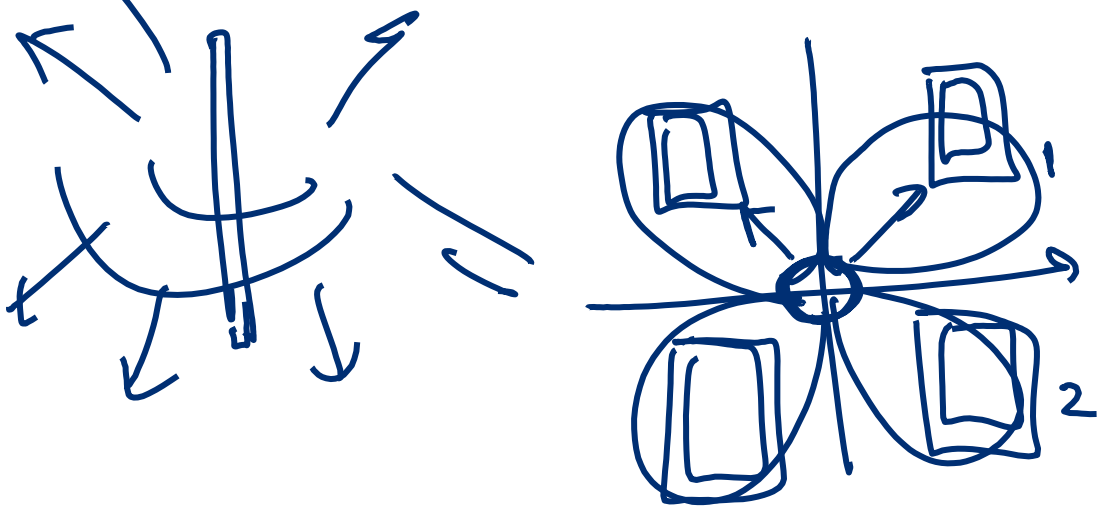
Spatial Reuse



$d_1 \gg d_2$

$r_2(t) = \frac{S}{d_1^2} S_1(t) + \frac{S}{d_2^2} S_2(t)$

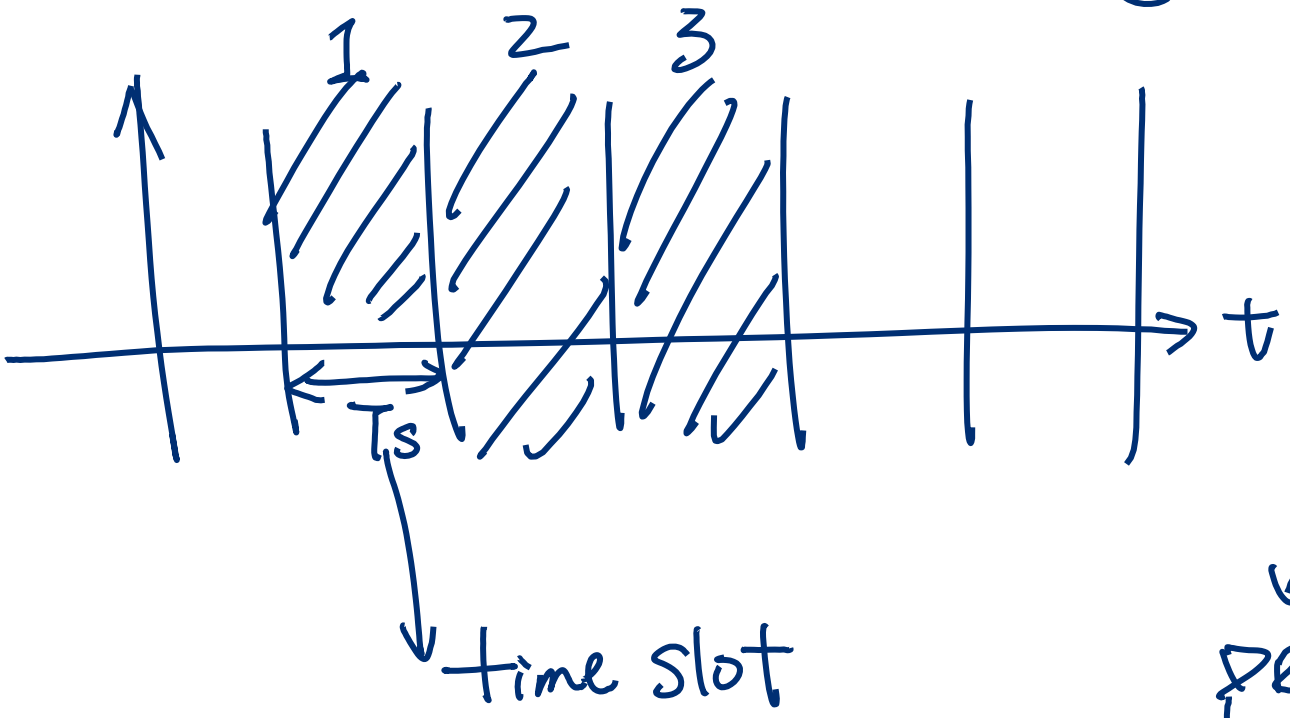
D

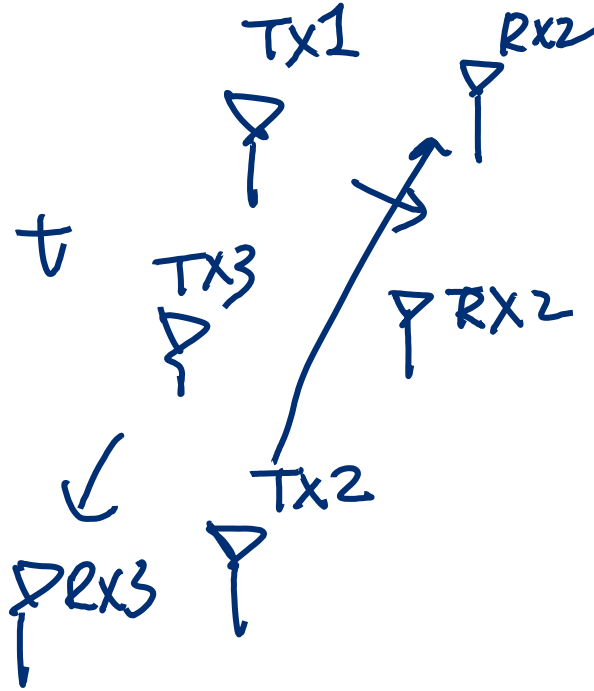


$d_1 \gg d_2$

$r_2(t) = S_1(t) + S_2(t)$

2. Time-Division Multiplexing





3. Code Division Multiplexing

CDMA

4. Frequency Multiplexing

$S_1(t) = \cos(\omega_c t)$ $\quad \omega_c$ $\quad f_c$ $\quad$ c: carrier wave

$$\int_0^T r(t) \times \cos(\omega_c t)\, dt = \int_0^T \cos(\omega_1 t)\cos(\omega_1 t) + \cos(\omega_2 t)\cos(\omega_1 t)\, dt$$

$S_1(t) + S_2(t)$

$= \cos(\omega_1 t) + \cos(\omega_2 t)$ → 0

$\cos(\omega_3 t)\cos(\omega_4 t)$ ($2\omega_3$)

$= \frac{1}{2}\cos((\omega_3+\omega_4)t) + \frac{1}{2}\cos((\omega_3-\omega_4)t)$ (≈ 0)

① $\omega_3 = \omega_4$

② $\omega_3 \neq \omega_4$

$\int_0^T \cos(\tilde{\omega} t)\, dt \approx 0$