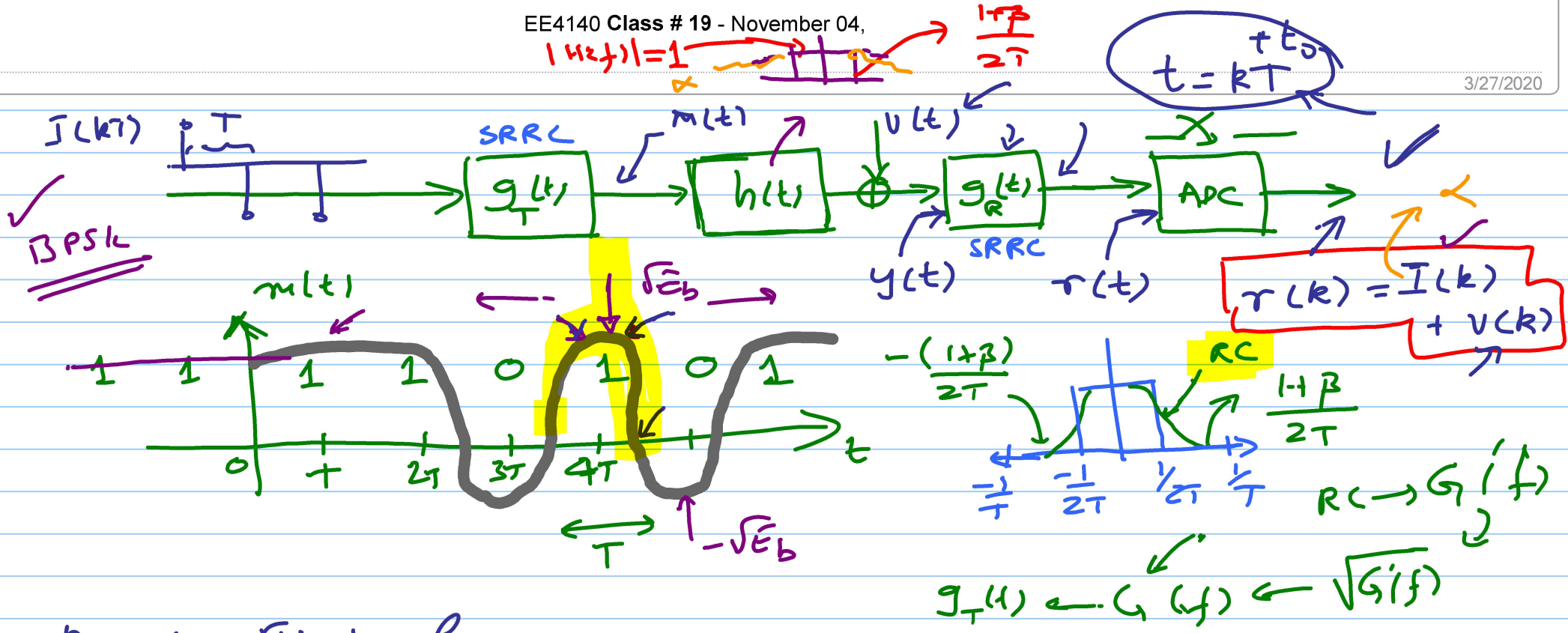
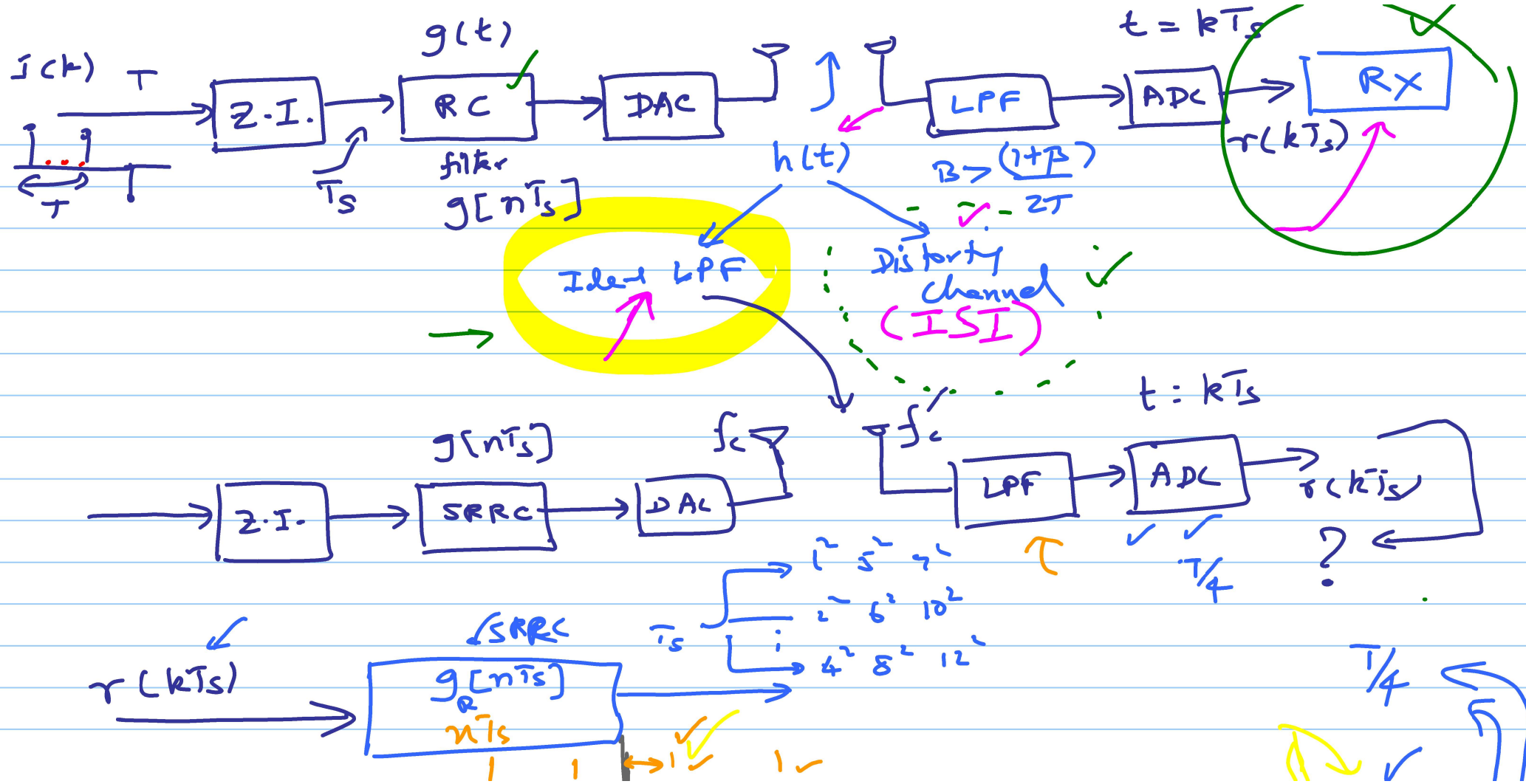
EE4140 **Class # 19** - November 04,

Note Title 3/27/2020

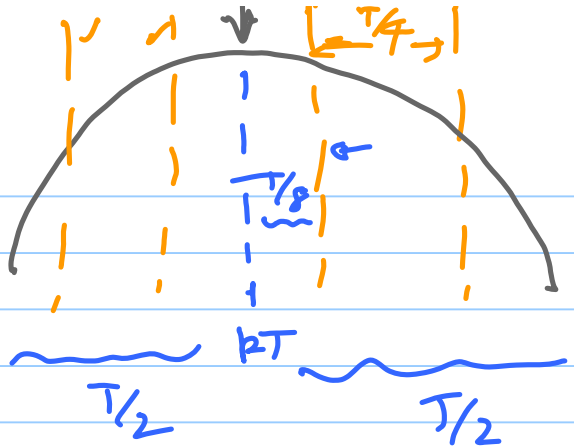


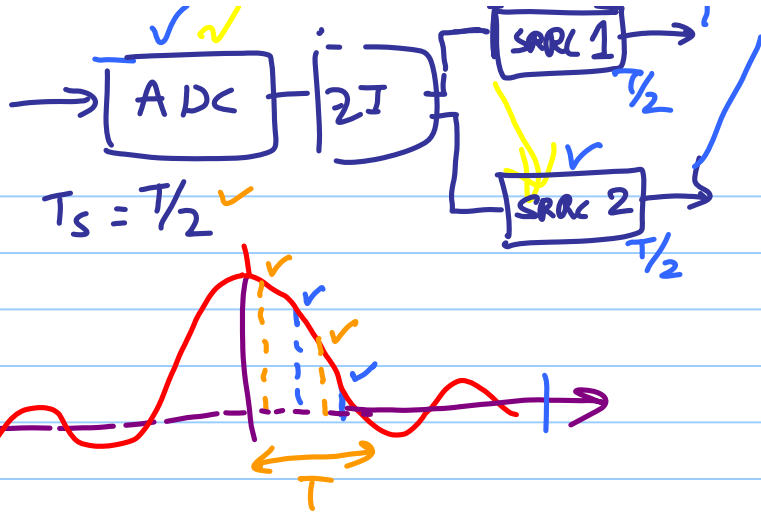
Recall Timing Recovery


I(k)
T
Z.I.
g(t)
RC
filter
DAC
T_s
h(t)
LPF
ADC
RX
$t = kT_s$
$r(kT_s)$
$B > \frac{(1+\beta)}{2T}$
$g[nT_s]$
Ideal LPF
Distorted channel (ISI)
SRRC
f_c
$t = kT_s$
$T/4$
τ
$r(kT_s)$
?
1^2 5^2 9^2
2^2 6^2 10^2
4^2 8^2 12^2
$g_R[nT_s]$
nT_s

T/8

$T_s = T/4$





* What about Carrier Recovery ?

$m_I(t) + j\, m_Q(t)$

± 1 ppm — f_c Tx → $s(t) = \mathrm{Re}\{\tilde{s}(t)\, e^{j2\pi f_c t}\}$ → Rx — ± 1 ppm — f_c'

$f_c = 10$ MHz

parts per million

Total ppm = 2 ppm

→ $m_I(t)\cos 2\pi f_c t + m_Q(t)\sin 2\pi f_c t$

2 ppm ⟶ 10 MHz

$10 \times 10^{6} \times 2 \times 10^{-6} = 20$ Hz.

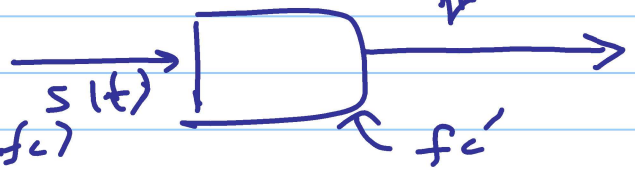
max error $\left(f_c - f_c'\right) = \pm 20$ Hz ⟵ CFO

⟶ 3-3 GHz

Δf

f_c''

Assume accurate timing

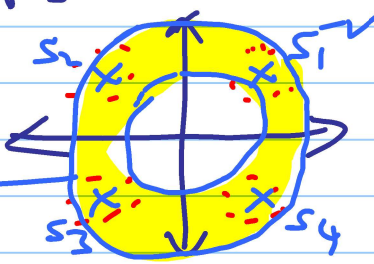


Exercise: If $\Delta f = 0$

$r(k) = s_i(k) + v(k)$

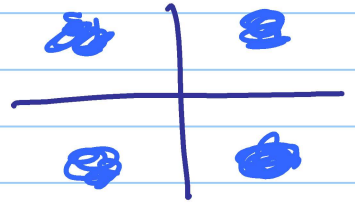
$\pm \sqrt{E_b} \pm j\sqrt{E_b}$

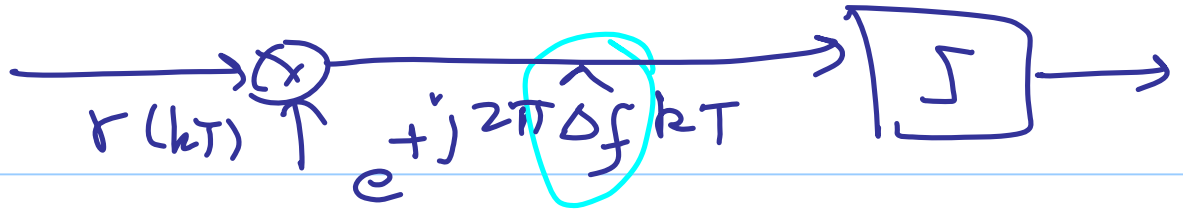
kT

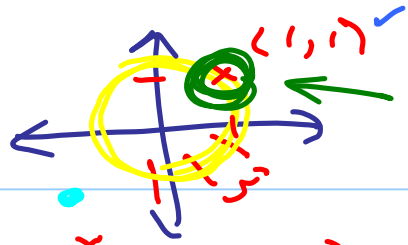


Exercise: If $\Delta f \neq 0$

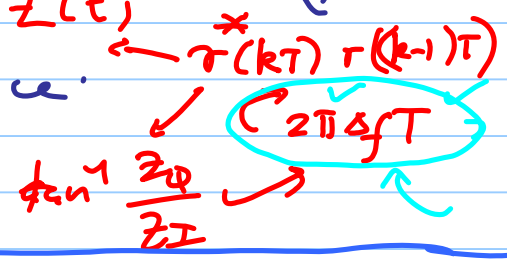
$$r(kT) = s_i(kT)\, e^{-j 2\pi \Delta f\, kT} + v(kT)$$

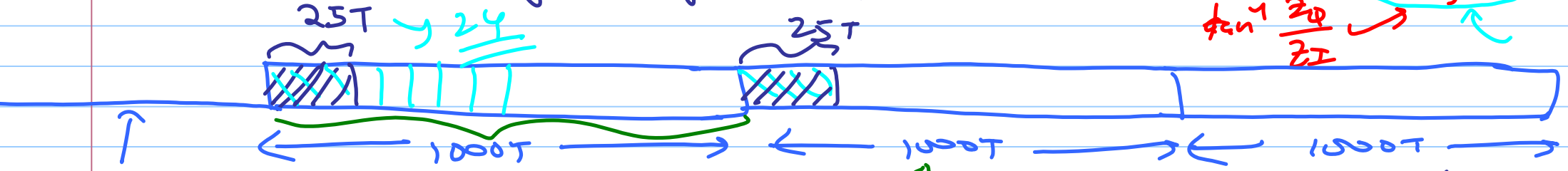






Carrier Recovery using a "pilot" sequence.





→ 4th Power Loop (QPSK)

→ $2\pi(4\Delta f)T$

revealed by the $\tan^{-1}(\cdot)$

$r^4(k)$ ← $r(k) = \left(1 \cdot e^{j\theta(k)}\right)^4$

$\theta(k) \in \left(i \times \frac{\pi}{2}\right)$

$i = 0, 1, 2, 3$

$\frac{\pi}{2} = \frac{2\pi}{4} \times 4$