CT - ASSIGNMENT - 4

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(1) Consider a first order loop

$H(s) = 1$

input phase $\theta_i(t) = kt^2$

$$t^n \xrightarrow{\text{Laplace}} \frac{n!}{s^{n+1}}$$

so, $kt^2 \xrightarrow{\text{Laplace}} \frac{k\,2!}{s^3} = \theta_i(s)$

Using small error analysis

$$\frac{\theta_o(s)}{\theta_i(s)} = \frac{s}{s+kG(s)}$$

$$\theta_o(s) = \frac{s}{s+kG(s)} \cdot \theta_i(s)$$

$$\Rightarrow \theta_o(s) = \frac{2k}{s^2(s+kG(s))}$$

to track signal,

$$\lim_{s \to 0} s\theta_o(s) = 0.$$

$$\lim_{s \to 0} \frac{2k}{s(s+kG(s))} = \infty.$$

so, we cannot track the signal.

for $G(s) = \frac{s+a}{s}$

$$\lim_{s \to 0} \frac{2K}{s\left(s + \frac{K_c}{s}(s+a)\right)}$$

$$= \lim_{s \to 0} \frac{2K}{s^2 + K_c(s+a)}$$

$$= \boxed{\frac{2K}{K_c a}}$$

So, we can track incomming signal for $G(s) = \frac{s+a}{s}$ with const. phase $= \frac{2K}{K_c a}$

Now, $G(s) = \frac{s^2+as+b}{s^2}$

$$\lim_{s \to 0} \frac{2K}{s\left(s + \frac{K_c}{s^2}(s^2+as+b)\right)}$$

$$\lim_{s \to 0} \frac{2Ks}{s^4 + K_c s^2 + K_c a s + K_c b} = 0$$

So, we can track Ru signal with zero phase diff.

(2)

a) Given $f_{IF} = 250\,MHz$
$= 0.25\,GHz$

$f_{LO} \in (1.9, 2.25)\,GHz$

Passband received signal,

$f_{RF} \in (1.8, 1.801)\,GHz.$

$f_{IF} = |f_{RF} - f_{LO}|$

$\Rightarrow$ $f_{LO} \in (1.55, 1.551)$ or $(2.05, 2.051)\,GHz.$

not possible (f_{LO})

So, $f_{LO} = f_{RF} - f_{IF} \in (1.8, 1.801)\,GH.$

Extra image frequency. $f_{IM} = f_{LO} + f_{IF}$
$\in (2.3, 2.301)\,GHz.$

Here we don't consider the 900 MHz band, as the obtained f_{LO} values don't lie in the mentioned range.

RF filter should allow frequencies of (1.8, 1.801) GHz

bandwidths of few MHz can be chosen as there are no other frequency components in few MHz range.

IF filter: should allow frequencies around 250 MHz → (249.5, 250.5) MHz.

(b) We have,

$f_{RF} \in (900, 901)$ MHz.

$f_{IF} = 250$ MHz

$\therefore$ f_{LO} can be (1150, 1151) MHz (not possible) or (650, 651) MHz

↓

f_{LO}

image frequency at $(f_{LO} - f_{IF})$ as RF is at $(f_{LO} + f_{IF})$

$\therefore$ $f_{IM} = 400$ MHz ± 1 MHz

RF filter:

Allow frequencies of (900, 901) MHz.

Bandwidth a few MHz

IF filter:

Allow frequencies 250 MHz.