CT Assignment-4

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1) Small error PLL,

i) S.T. First-order loop cannot track incoming signal whose instantaneous frequency varying linearly with time.

i.e. $\theta_i(t) = kt^2$

For tracking incoming signal,

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

$\theta_i(t) \longleftrightarrow \theta_i(s)$

We know that $t^n \longleftrightarrow \frac{n!}{s^{n+1}}$

$\Rightarrow \theta_i(s) = \frac{2k}{s^3}$

For a first order system, $\boxed{\frac{\theta_o(s)}{\theta_i(s)} = \frac{s}{s+kH(s)}}$ — ①

For $H(s) = 1$

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

$\lim_{s \to 0} s\,\theta_o(s) = \lim_{s \to 0} \frac{2k}{s(s+k)}$

$= \infty \; (\neq 0)$

$\Rightarrow$ We cannot track the signal

ii) It can be tracked only when we have zero-phase error i.e. $H(s) = \frac{s^2 + as + b}{s^2}$

Substituting this in — ①,

$$\frac{\theta_0(s)}{\frac{2K}{s^3}} = \frac{s}{s + K\frac{(s^2 + as + b)}{s^2}}$$

$$\Rightarrow \theta_0(s) = \frac{2K}{s^2} \times \frac{s^2}{s^3 + K(s^2 + as + b)}$$

$$\theta_0(s) = \frac{2K}{s^3 + K(s^2 + as + b)}$$

$$\lim_{s \to 0} s\theta_0(s) = \lim_{s \to 0} \frac{2sK}{s^3 + Ks^2 + Kas + Kb}$$

Numerator $= 0$ & denominator is Kb

$$\Rightarrow \boxed{\lim_{s \to 0} s\theta_0(s) = 0}$$

$\Rightarrow$ We can track the signal.

2) Given,
Dual band radio operates at 900 MHz and 1.8 GHz
channel spacing in each band is 1 MHz.
Superheterodyne receiver with IF 250 MHz.
LO uses synthesizer tunable from 1.9 GHz to 2.25 GHz

a) Superhet receiver should receive passband restricted to 1800 MHz - 1801 MHz.

$f_{RF} = 1.8$ to 1.801 GHz Avg $f_{RF} = 1.8005$ GHz

We know that $f_{IF} = |f_{RF} - f_{LO}|$.

$\Rightarrow 0.25 = |1.8 \text{ to } 1.801 - f_{LO}|$

$\Rightarrow f_{LO} = 2.05$ to 2.051 or $f_{LO} = 1.55$ to 1.551

Given that we ~~have~~ use 1.9 GH to 2.25 GHz

$\therefore \boxed{f_{LO} = 2.05 \text{ to } 2.051 \text{ GHz}}$ Avg $f_{LO} = 2.0505$ GHz

~~we have channel spacing of 1 M~~

$f_{IM} = f_{LO} + f_{IF}$ where f_{IM} is frequency of image

$\Rightarrow f_{IM} = 2.05 \text{ to } 2.051 + 0.25$ GHz

$\Rightarrow \boxed{f_{IM} = 2.3 \text{ to } 2.301 \text{ GHz}}$

On average, $f_{IM} = 2.3005$ GHz

RF Filter: Should pass 1800 - 1801 MHz

$\Rightarrow$ Centre is 1800.5 MHz and allows 1800-1801

~~this signal but~~

and rejects image frequency 2300 - 2301 MHz

So the bandwidth ~~cutoff~~ can ~~should~~ be ideally 2-5 MHz from 1800.5 MHz

IF Filter: It is at 250 MHz & should pass the message in 249.5 to 250.5 with a sharp-cut off beyond.

b) $f_{RF} = 900$ to 901 MHz $\therefore$ Avg $f_{RF} = 900.5$ MHz

We know that $f_{IF} = |f_{RF} - f_{LO}|$

$250 = |900 \text{ to } 901 \text{ MHz} - f_{LO}|$

$\Rightarrow f_{LO} = 1150$ to 1151 MHz or $f_{LO} = 650$ to 651 MHz

Range 1.9 GHz to 2.25 GHz.

$\Rightarrow f_{LO} = 0.65 - 0.651$ GHz (because it is a multiple)

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

$\Rightarrow f_{IM} = (0.65 \text{ to } 0.651) - 0.250$ GHz

$= 0.4$ to 0.401 GHz

RF Filter: Should pass 900 - 901 MHz and reject f_{IM} which is around 400 MHz.

$\Rightarrow$ centre is at 900.5 MHz and bandwidth can be ~~cut off is~~ ideally 2-5 MHz

IF Filter: It is at 250 MHz & should pass the message in 249.5 to 250.5 with a sharp cut-off beyond.