ECE 145b Homework#5 Solutions

#1

$f_{IF} = 10.7\,MHz \qquad f_{RF} = 88\,MHz$

$f_{LO} = f_{RF} \pm f_{IF} = 77.3\,MHz$ or $98.7\,MHz$

$f_{image} = 66.6\,MHz, \quad 109.4\,MHz$

#2

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

Bandwidth must be less than $2 \cdot f_{IF}$

For $f_{RF} = 88\,MHz$, image frequency $109.4\,MHz$ won't be rejected.

#3

$G = \frac{P_{out}}{P_{in}} = 10\,dB$

Output Power

f_1, f_2	$(2f_1 - f_2), (2f_2 - f_1)$
0dBm	-30dBm
1dBm	-27dBm
⋮	⋮
15dBm	15dBm = OIP3

$\frac{OIP3}{G} = IIP3 = 5\,dBm$

#4

$f_1 = 0.99$ GHz -20dBm

$f_2 = 1.00$ GHz -30dBm

$f_3 = 1.01$ GHz -40dBm

$G = 10$dB IIP3 = 0dBm

OIP3 = 10dBm

$P_1 = -10$dBm
$P_2 = -20$dBm
$P_3 = -30$dBm

$$OIP3 = P(f_1) + \tfrac{1}{2}(P(f_2) - P(2f_1 - f_2))$$
$$P(2f_1 - f_2) = 2P(f_1) - 2 \cdot OIP3 + P(f_2)$$
$$P(2f_2 - f_1) = 2P(f_2) - 2 \cdot OIP3 + P(f_1)$$

} in dB

$2f_1 - f_2 = 0.98$ GHz $P(.98\text{GHz}) = -60$dBm

$2f_2 - f_1 = 1.01$ GHz $P(1.01\text{GHz}) = -70$dBm signal dominates $P(1.01\text{GHz}) \approx -30$dBm

$2f_1 - f_3 = 0.97$ GHz $P(.97\text{GHz}) = -70$dBm

$2f_3 - f_1 = 1.03$ GHz $P(1.03\text{GHz}) = -90$dBm

$2f_2 - f_3 = 0.99$ GHz $P(.99\text{GHz}) \approx -10$dBm

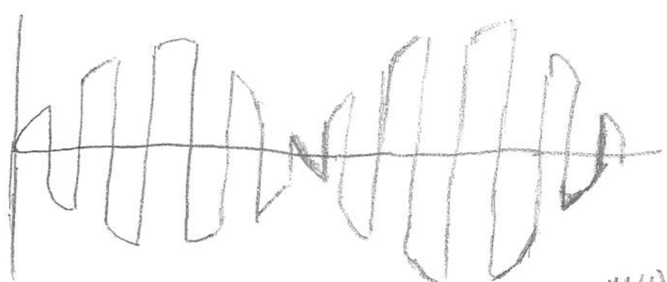
$2f_3 - f_2 = 1.02$ GHz $P(1.02\text{GHz}) = -100$dBm

$P(1\text{GHz}) \approx -20$dBm

#5

a)

$V_{IF}(t)$



b)

$M(t) = 1V\,\text{square}(\omega_{LO} t)$

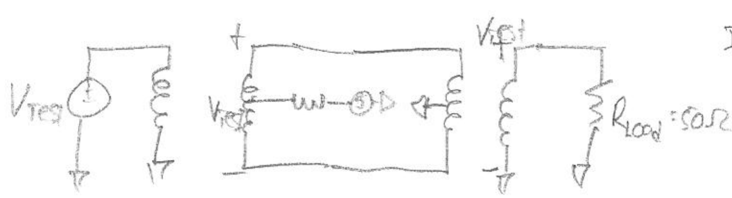
$= \frac{4}{\pi}\left[\cos(\omega_{LO}t) + \frac{\cos(3\omega_{LO}t)}{3} + \frac{\cos(5\omega_{LO}t)}{5} + \dots\right]$

$1mV \cos(\omega_{RF} t) \cdot \frac{4}{\pi} \cos(\omega_{LO} t)$

$\Rightarrow \frac{4}{\pi} mV \left[\frac{1}{2}\cos((\omega_{RF} + \omega_{LO})t) + \frac{1}{2}\cos((\omega_{RF} - \omega_{LO})t)\right]$

Amplitude: $\frac{2}{\pi} mV$

c)



$I_{test} = \frac{V_{test}}{50\Omega}$

Input impedance: 50Ω

#7

$f_{RF} = 60GHz$

$f_{IF} = 10GHz$ $\qquad f_{LO} = 50GHz$ or $70GHz$

choose 50GHz

$3f = f_{LO}$ $\qquad f = 16.66\ GHz$

$\frac{\cos(3\omega t)}{3}$ instead of $\cos(\omega t)$, effective gain is $1/3$

images: $40GHz$, $16.66GHz \pm 10GHz$, $(5 \cdot 16.66\ GHz) \pm 10GHz$

#8

$V_{IF} = (g_m R_L) V_{RF}$

$(100mS)(1K\Omega)(10mV) = \boxed{1V_{RMS} = V_{IF}}$