1. Consider the sliding-IF receiver shown in Fig. 2.1.

(a) Determine the required LO frequency range. (assume the second IF is zero, and the input RF range is $[f_1, f_2]$)

(b) Determine the image frequency range.

(c) Is this architecture preferable to that in Fig. 2.2? Why?

(d) Determine some of the mixing spurs in the architecture of Fig. 2.1 (use f_{in} to express f_{int})

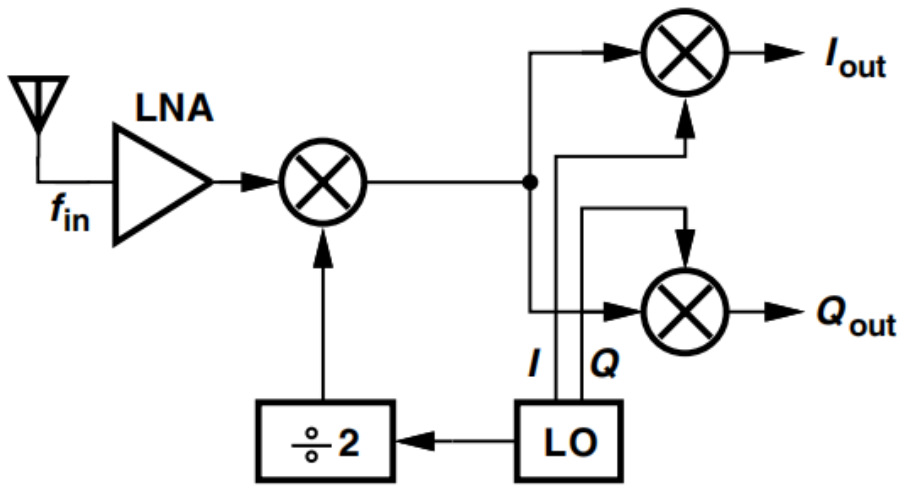


Fig. 2.1

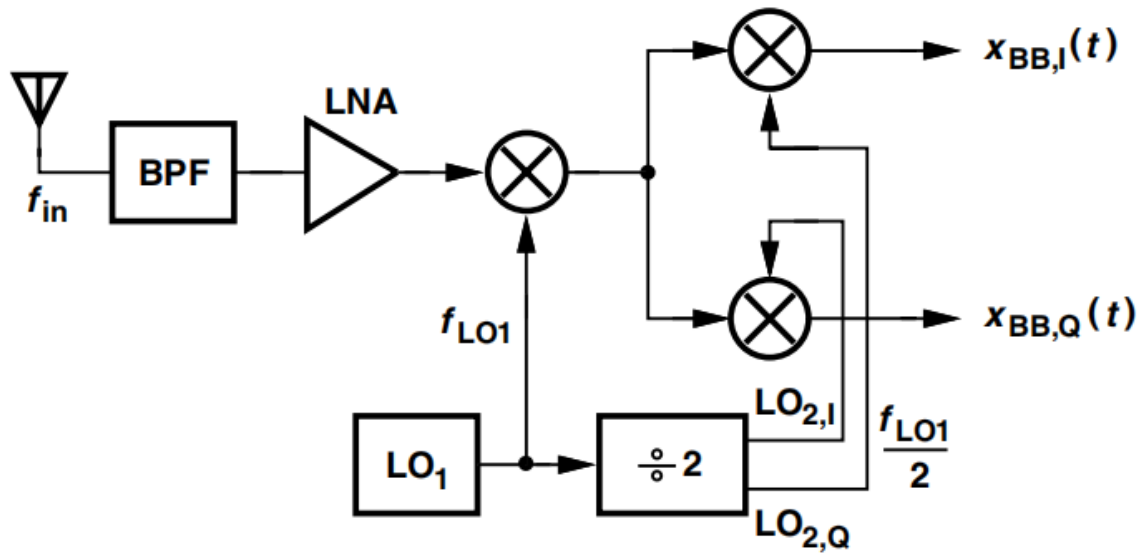


Fig. 2.2

a) Assume the second IF is zero

$$f_{in} - \frac{1}{2} f_{LO} - f_{LO} = 0$$

$$f_{LO} = \frac{2}{3} f_{in}$$

If the input RF range is $[f_1, f_2]$, the LO frequency range is $\left[\frac{2}{3} f_1, \frac{2}{3} f_2\right]$

b) As follows

$$2 \cdot \left(\frac{1}{2} f_{LO}\right) - f_{\text{in}} = f_{image}$$

$$\mathrm{f_{image}} = -\frac{1}{3} \mathrm{f_{in}}$$

The range of image freq is $\left[-\frac{1}{3} f_2, -\frac{1}{3} f_1\right]$

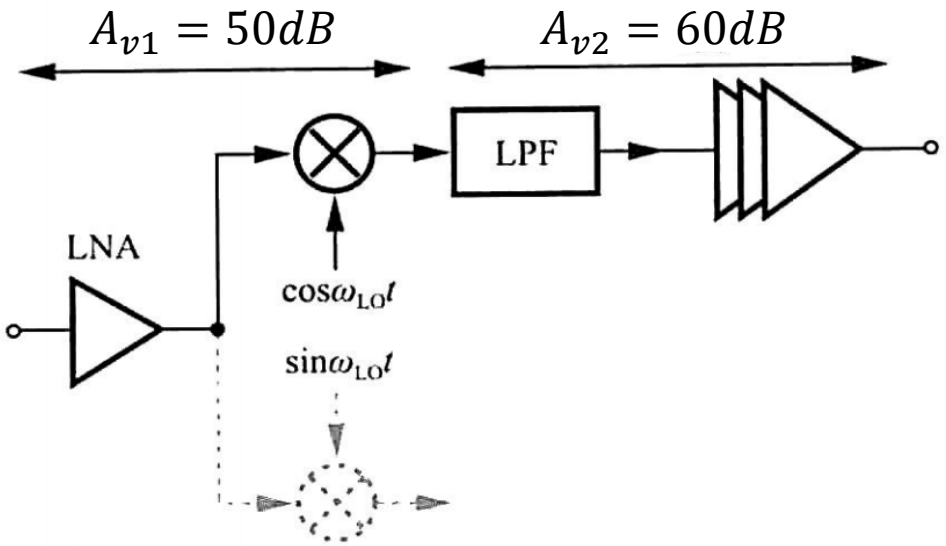
c) No

Because the image frequency range is not filtered, which would interfere with subsequent signal processing. And the I/Q mixers operate at much higher frequency, which is difficult to design

d) Mixing spurs:

$$f_{int} = \pm m f_{LO1} \pm n f_{LO2} = \left(\pm \frac{m}{2} \pm n\right) \cdot \frac{2}{3} f_{in}$$

2. **A direct-conversion receiver incorporates a voltage gain of 50 dB from the LNA input to each mixer output and another gain of 60 dB in the baseband stages following the mixer. If the LO leakage at the LNA input is equal to -80 dBm, determine the offset voltage at the output of the mixer and at the output of the baseband chain.**



If a sinusoid $V_0 cos\omega_{in} t$ is applied to the LNA input, then the baseband signal at the mixer output, $V_{bb}\cos(\omega_{in} - \omega_{LO})\, t$, has an amplitude given by

$$V_{bb} = A_{v1} \cdot V_0$$

Thus, for an input $V_{leak} cos\omega_{LO} t$, the dc value at the mixer output is equal to

$$V_{dc} = A_{v1} \cdot V_{leak}$$

Since $A_{v1} = 316.23$ and $V_{leak} = 31.62\mu V$, we have $V_{dc} = 10mV$. Amplified by another 60dB, this offset reaches 10V at the baseband ouput.

3. Consider the Trade-off between Image Rejection and Channel Selection, and describe the advantages and disadvantages of high ω_{IF} and low ω_{IF}

Shown in Fig. 4.14 are two cases corresponding to high and low values of IF so as to illustrate the trade-off. A high IF [Fig. 4.14(a)] allows substantial rejection of the image whereas a low IF [Fig. 4.14(b)] helps with the suppression of in-band interferers. We thus say heterodyne receivers suffer from a trade-off between image rejection and channel selection.