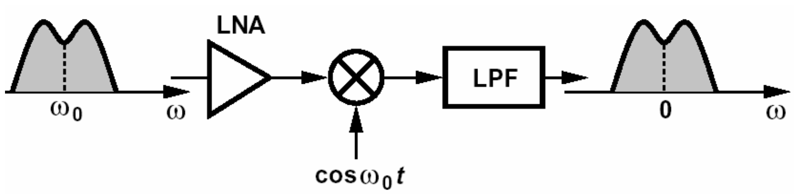
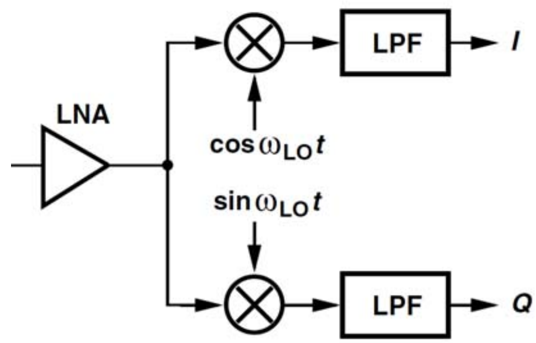
Transceiver Architectures (II)

Direct-Conversion (aka Homodyne or Zero-IF) Receivers



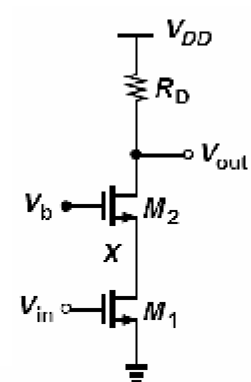


- No image-rejection necessary → LNA need not drive 50 ohms.
- Channel-selection performed by low-pass filters.
- Number of mixing spurs is reduced considerably.

Issues:

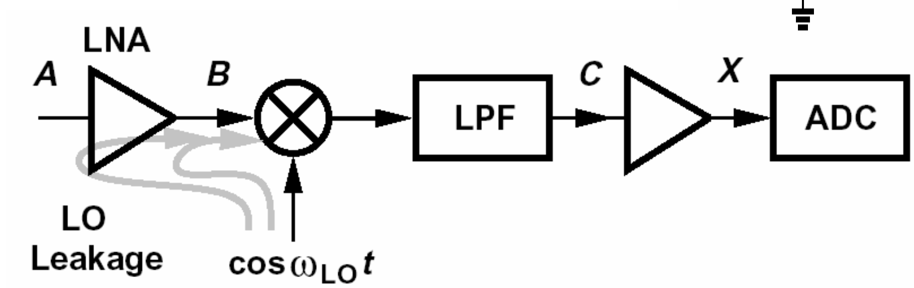
1. LO Leakage:

Example: Study the LO leakage in a cascode LNA.



(Is this serious in het. RX?)

2. DC Offsets



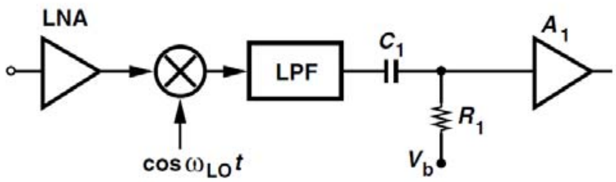
(Is this serious in het. RX?)

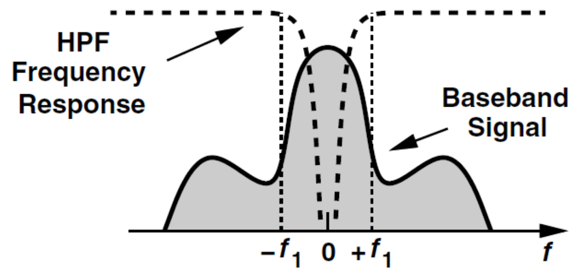
- **Example**

Explain why the dc offsets observed at the I and Q outputs are often unequal?

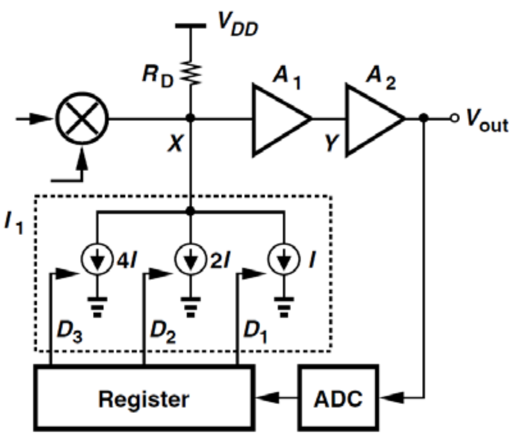
- **DC Offset Removal Techniques**

- High-Pass filtering

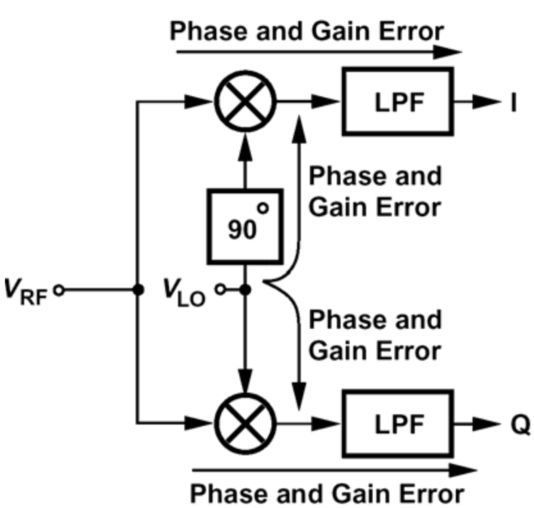


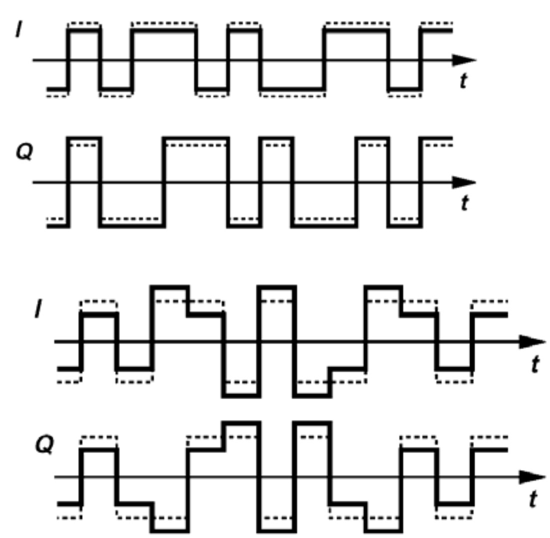


- Digital Offset Storage



3. I/Q Mismatch

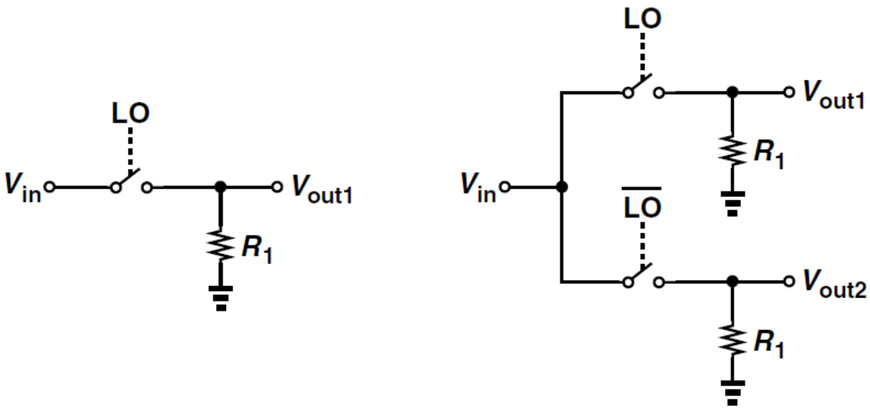




(Is I/Q mismatch serious in het. RX?) How much mismatch is tolerable?

4. Even-Order Distortion

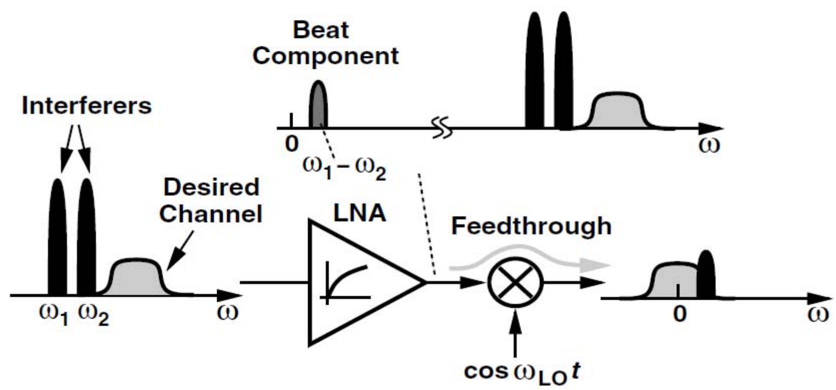
What happens if a mixer has asymmetry?



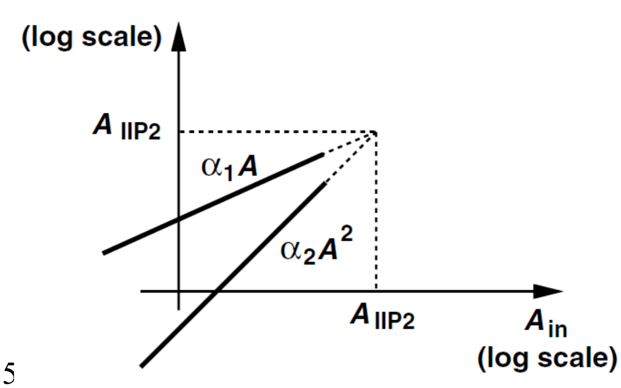
What happens if LNA has even-order nonlinearity?

$$V_{out}(t) = \alpha_1 V_{in}(t) + \alpha_2 V_{in}^2(t)$$
$$= \alpha_1 A(\cos\omega_1 t + \cos\omega_2 t) + \alpha_2 A^2 \cos(\omega_1 + \omega_2)t$$
$$+ \alpha_2 A^2 \cos(\omega_1 - \omega_2)t + \cdots,$$

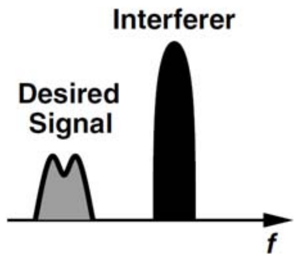
What happens in the receiver?



How do we quantify this effect? Define "IP2:"



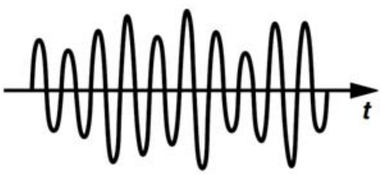
- Another important effect: Even-order distortion also demodulates AM components:



$$x_{in}(t) = [A_0 + a(t)]\cos[\omega_c t + \phi(t)]$$

$$\alpha_2 x_{in}^2(t) = \alpha_2\left[A_0^2 + 2A_0 a(t) + a^2(t)\right]\frac{1 + \cos[2\omega_c t + 2\phi(t)]}{2}$$

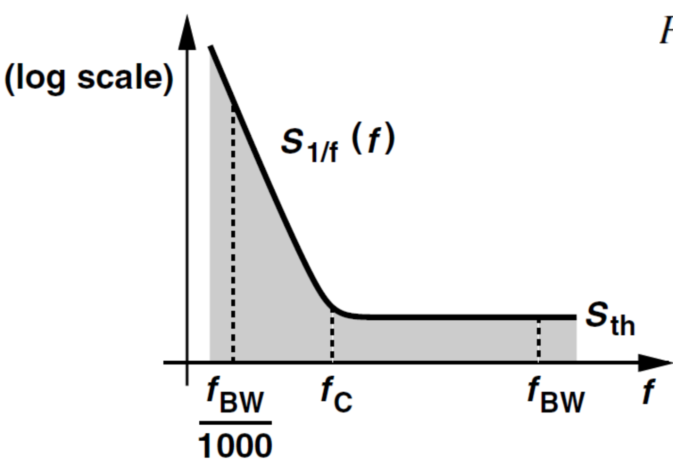
Interferer



- Why can't we just ac couple to the mixer?

Refer to examples in the book.

5. Flicker Noise → Compute noise power with and without flicker noise to see the penalty:

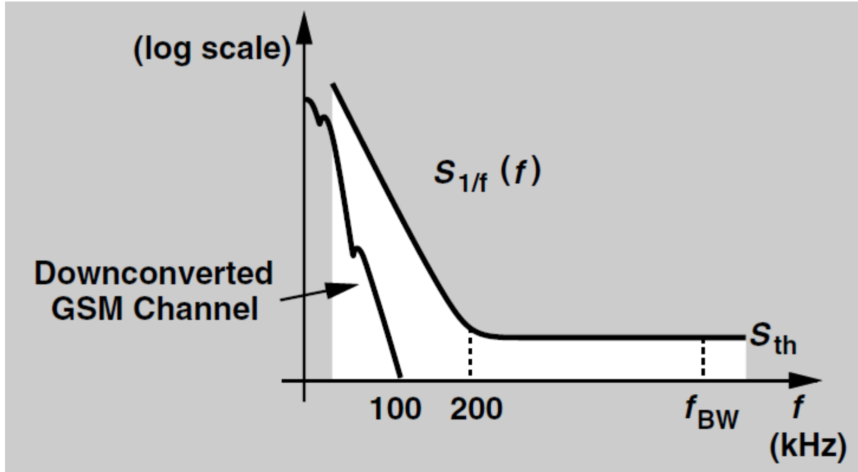


$$P_{n1} = \int_{f_{BW}/1000}^{f_c} \frac{\alpha}{f}df + (f_{BW} - f_c)S_{th}$$

$$= \left(5.9 + \ln\frac{f_c}{f_{BW}}\right)f_c S_{th} + f_{BW}S_{th}$$

$$\frac{P_{n1}}{P_{n2}} = 1 + \left(5.9 + \ln\frac{f_c}{f_{BW}}\right)\frac{f_c}{f_{BW}}$$

Example: Effect of 1/f noise in GSM



Suppose 1/f corner is 200 kHz.

Total noise power:

$$P_{n1} = \int_{27\text{ Hz}}^{100\text{ kHz}} \frac{\alpha}{f} df$$
$$= f_c \cdot S_{th} \ln \frac{100\text{ kHz}}{27\text{ Hz}}$$
$$= 8.2 f_c S_{th}.$$

How much is the penalty?

What is the effect of receiver gain on this penalty?