Low-power radio design for the IoT
Exercise 3 (10.03.2022)

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Problem 1 Nonlinearity and Time Variance

A list of input-output equations for several systems are given below. The instantaneous input is $x(t)$ and the instantaneous output is $y(t)$.

 a) $2y(t) = 5x(t) + 7$

 b) $2y(t) = 5x^2(t) + x(t)$

 c) $2t\, y(t) = 5x(t) + 7$

 d) $\frac{dy(t)}{dt} + 2y(t) = 3x(t)$

 e) $\frac{d^2 y(t)}{dt^2} + 3y(t)\frac{dy(t)}{dt} = 5x(t)$

- Classify each system as time invariant or time variant, linear or nonlinear and with memory or memoryless.

Problem 2 Third-Order Input Intercept Point

Consider the scenario shown in Fig. 1, where $\omega_3 - \omega_2 = \omega_2 - \omega_1$ and the band-pass filter (BPF) provides an attenuation of $17\,\mathrm{dB}$ at ω_2 and $37\,\mathrm{dB}$ at ω_3.
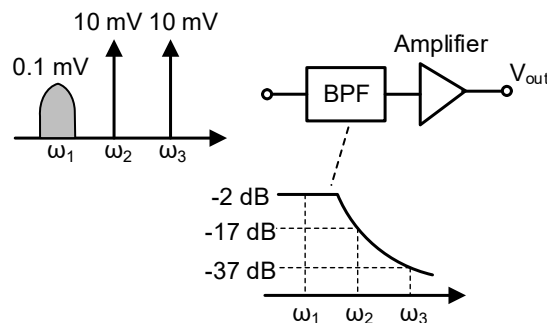

Figure 1: Cascade of BPF and amplifier.

- Compute the A_{IIP3} of the amplifier such that the intermodulation product falling at ω_1 is $20\,\mathrm{dB}$ below the desired signal.

- Suppose an amplifier with a voltage gain of $10\,\mathrm{dB}$ and $A_{IIP3} = 3.979\,\mathrm{dBm}$ precedes the band-pass filter. Calculate the A_{IIP3} of the overall chain (neglect the second order nonlinearities and the nonlinearity of the BPF).

Problem 3   Cascade of Nonlinear Stages

The circuit in Fig. 2 is a cascade of two identical common-source stages loaded by a resistor, R_D.
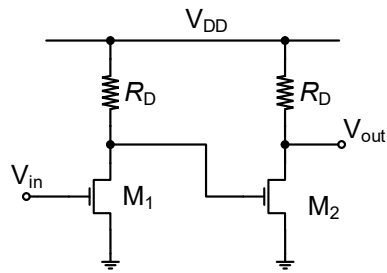

Figure 2: Cascade of common source stages.

- Assume that each transistor operates in saturation and SI and determine the A_{IIP3} of the cascade.