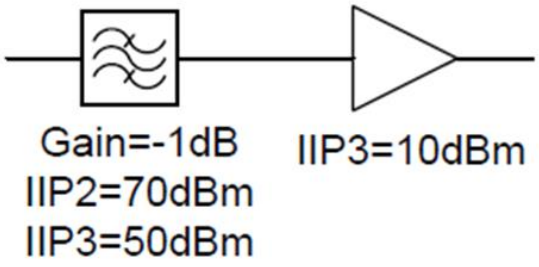
EE142 Problem Set 8

Vighnesh Iyer

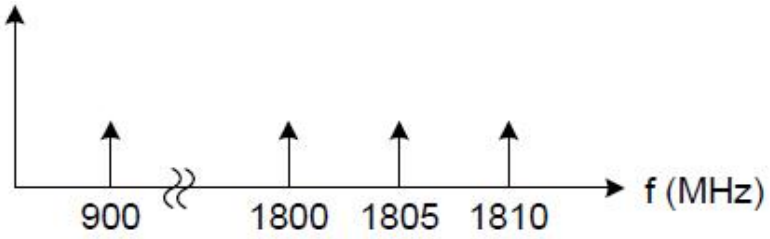
November 8, 2017

1 System Analysis

A wireless receiver front-end is shown below:



We would like to receive the channel at 1800MHz, while we have additional chanels at 900MHz, 1805MHz, and 1810MHz.



The minimum detectable signal at 1800MHz is -100dBm. The required signal to distortion ratio at the front-end output is 9dB.

(a) If the signal power at the 1810MHz channel is -33dBm, what is the maximum allowed power at the 1805MHz channel?

We can find the cascaded IIP3 of the front-end:

$$\frac{1}{IIP3^2} = \frac{1}{IIP3_A^2} + \frac{a_1^2}{IIP3_B^2}$$

where the $IIP3$ terms in the above formula are voltages or currents.

Here are some useful equations to convert power to voltage, and convert power gain to voltage gain:

$$\begin{aligned}
\text{Power Gain in dB} &= 10\log_{10}(\text{Power Gain in Linear Units}) \\
\text{Power Gain in Linear Units} &= 10^{\text{Power Gain in dB}/10} \\
\text{Voltage Gain} &= \sqrt{\text{Power Gain in Linear Units}} \text{ assuming same } R_{in}, R_{out} \\
\text{Power in dBm} &= 10\log_{10}(\frac{\text{Power in Watts}}{10^{-3}}) \\
\text{Voltage Induced} &= \sqrt{10^{-3}\cdot 10^{\text{Power in dBm}/10}\cdot 2R} \\
\text{Power Delivered in dBm} &= 10\cdot\log_{10}(\frac{V^2}{2R}/10^{-3})
\end{aligned}$$

We will assume operation in a 50Ω environment.

$$\begin{aligned}
IIP3_A &= 50 \text{ dBm} \rightarrow VIIP3_A = 100 \text{ V} \\
IIP3_B &= 10 \text{ dBm} \rightarrow VIIP3_B = 1 \text{ V} \\
a_1 &= 0.8912 \text{ V/V} \\
VIIP_3 &= 1.1219 \text{ V} \\
IIP_3 &= 11 \text{ dBm}
\end{aligned}$$

As expected, the second stage's IIP3 dominates the cascaded IIP3. The power present at 1800MHz is caused by the intermodulation products of 1805MHz and 1810MHz:

$$V_{out,1800} = \frac{3a_3}{4}A_{1805}^2\cdot A_{1810}$$

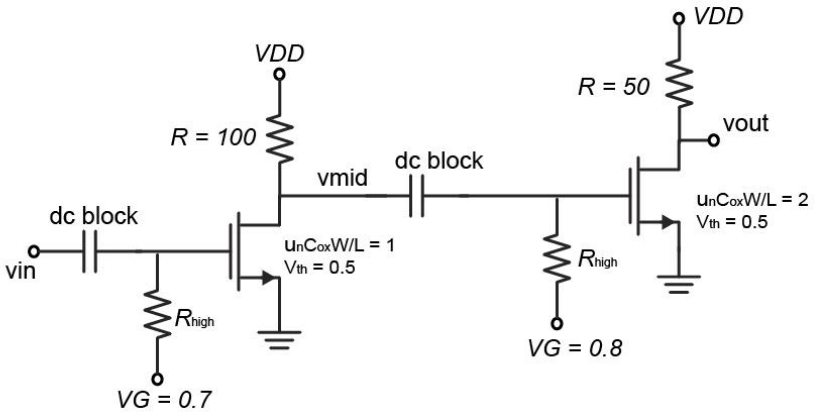
where A_x is the voltage at x MHz. We can find a_3 from IIP3:

$$\begin{aligned}
IIP3 &= \sqrt{\frac{4}{3}\frac{|a_1|}{|a_3|}} \\
a_3 &= 0.944 \\
V_{out,1800} \leq V(-109dBm) &\rightarrow P_{1805} \leq -26.5 \text{ dBm}
\end{aligned}$$

(b) What is the required spec for the amplifier IIP2 if the signal power at the 900MHz channel can be as high as -30dBm?

2 Distortion Analysis

In this problem you will do distortion analysis for a frequency-independent amplifier.


VDD
R = 100
vmid
dc block
dc block
vin
unCoxW/L = 1
Vth = 0.5
Rhigh
VG = 0.7
VDD
R = 50
vout
unCoxW/L = 2
Vth = 0.5
Rhigh
VG = 0.8