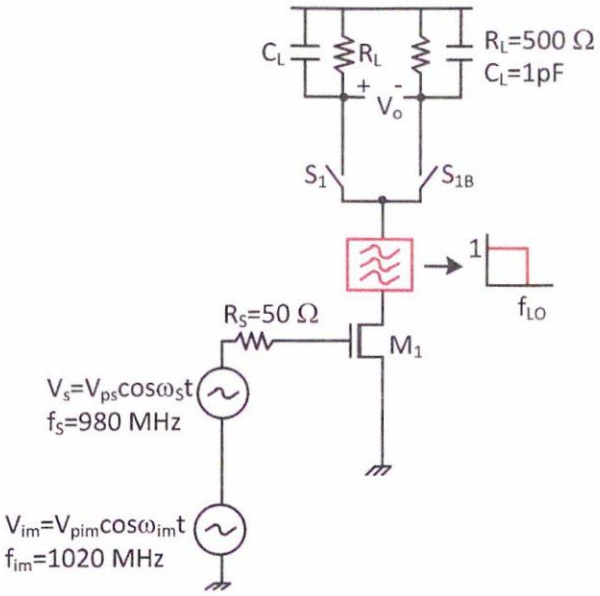

4) Now, in order to remove the image tone, let's apply ideal brick-wall type low pass filter (LPF) as shown above. Calculate output noise power and noise factor. Assume that the LPF is noiseless (5 pt).
(Note: the image rejection filer will also reject noise and help to improve SNR. In general, the M1 can be regarded as LNA and the switches (S1 and S1B) as mixer, respectively. You could understand the role of a filter between LNA and mixer through this example.)

$$\overline{V_{no}}^2 = \left(\frac{2}{\pi}\right)^2 \cdot 4KT\left(R_s g_m^2 + \frac{\gamma}{\alpha} g_m\right) R_L^2 + \underbrace{4KT R_L \times 2}_{\text{No-filtering of } R_L \text{ noise}}$$

↑ due to filtering

$$= 208.62 \times 10^{-18}\ V_{rms}^2/Hz$$

$$F = \frac{1}{\left(\frac{2}{\pi} g_m R_L\right)^2} \cdot \frac{\overline{V_{no}}^2}{\overline{V_{ni}}^2}$$

$$= \frac{1}{\left(\frac{2}{\pi} \cdot 34m \times 500\right)^2} \cdot \frac{208.62 \times 10^{-18}}{8.8 \times 10^{-21}}$$

$$= 2.15 \Rightarrow 3.327\ dB \Rightarrow \text{about } 3dB \text{ improvement.}$$