1. The circuit below is the receiver of a medical implant... It works by receiving a very strong signal at 25 MHz and a weaker, modulated signal at 100.5 MHz. The output is an IF signal at 500 kHz. That is:

\[ V_{\text{in}} = V_{\text{BIG}} \times \cos(2\pi \times 25 \times 10^6 \times t) + V_{\text{SIG}} \times \cos(2\pi \times 100.5 \times 10^6 \times t), \]

\[ V_{\text{out}} = G_{\text{COV}} \times V_{\text{SIG}} \times \cos(2\pi \times 500 \times 10^3 \times t) \]

(a) What is the \( g_m \) of the transistor as a function of time? (assume square-law, \( V_{\text{TH}} = 0 \).

(b) What is the Fourier series of \( G_m(t) \)

(c) For \( V_{\text{BIG}} = 200 \text{mV} \), what is the conversion gain of the mixer?

(d) Confirm in simulation using \( V_{\text{SIG}} = 20 \text{mV} \)

\[ V_{\text{DD}} = 0.4 \text{V} \]

\[ 80 \text{pF} \quad 2k\Omega \quad 80 \text{pF} \]

\[ W=25\mu\text{m} \quad L=1\mu\text{m} \]

\[ \text{VTO}=0\text{V} \quad \text{KP}=200\mu\text{A/V}^2 \quad \text{GAMMA}=0.6 \quad \text{Phi}=0.6 \quad \text{LAMBDA}=0.015 \]

\[ \text{CJ}=900\mu\text{F/m}^2 \quad \text{PB}=0.5\text{V} \quad \text{TOX}=7\text{nm} \quad \text{CGSO}=0.1\text{nF/m} \quad \text{CGDO}=0.1\text{nF/m} \]