A BJT mixer is shown below

\[ i_{osc} \quad v_{osc} \quad i_{s} \quad 5k \]

\[ +12V \quad 2k \quad \text{i.f.} \quad v_o \]

\[ 3k \quad 5k \quad 5.3k \quad C_1 \quad C_2 \]

\[ C_1 \text{ and } C_2 \text{ are large bypass capacitors. All tuned circuits are short circuits at frequencies other than their center frequency.} \]

If \( v_{osc} = 100 \text{mV peak and } \beta = 100 \), calculate the i.f. output voltage \( v_o \) for \( i_s = 1 \mu A \text{ rms}. \) Calculate the loading produced on the oscillator tuned circuit by the transistor.

2. A FET mixer is shown below.

\[ Bias \quad +5V \]

\[ M_1 \quad R_1 \quad 5k \Omega \quad C_1 \text{ Tuned to i.f.} \quad v_o \]

\[ R_2 \quad M_2 \]

\[ v_s(\omega_s) \quad C_2 \]

\[ L_s \quad R_s \quad 1k \Omega \]

\[ C_3 \quad v_o(\omega_o) \]
$C_1$ and $C_2$ are large. $R_2$ is large. $C_3$ injects the LO signal into $M_2$. The oscillator voltage $v_o = 2V_{rms}$ at frequency $110\text{MHz}$. $i_g$ is the input signal at $100\text{MHz}$. Both tuned circuits have $Q = 50$. Neglect the effect of $C_3$ when designing the input tuned circuit.

Select $C_3$ to inject an oscillator voltage of $0.5V$ o-p at the gate of $M_2$. Select $\frac{W}{L}$ of $M_2$ to give $(V_{GS2} - V_t) = 1V$ for $I_{D2} = 2mA$. Calculate the conversion voltage gain of your design. Specify all tank element values.

Data \[ \mu C_{ox} = 80 \mu A/V^2, \lambda = 0. \]

Assume a square law device characteristic.

3. A switching mixer is shown below.

![Diagram of a switching mixer](image)

Device data \[ \mu C_{ox} = 80 \mu A/V^2, \lambda = 0 \]

\[ \left( \frac{W}{L} \right)_1 = \left( \frac{W}{L} \right)_2 = 200 \]

Neglect capacitance effects.

Assume all FETs operate in saturation, $I_{D1} = I_{D2}$ for bias and $v_{osc}$ is large enough to switch the quad ideally.

Calculate the conversion voltage gain of the circuit from $v_i$ to $v_o$.

If an unwanted input signal at a frequency $29\text{MHz}$ with an amplitude of $1mV$ was received at $v_i$, how much output voltage would it produce at the i.f?