High Frequency BJT Transistor Model

\[ \begin{align*}
\text{pn-junction} & \quad \downarrow \quad \text{high freq model} \\
\frac{C_d}{C_j} & \quad \frac{C_j \circ}{1 - \frac{V_p}{V_{bi}}}^n \\
C_j & : \text{Junction capacitance} \\
C_d & : \text{Diffusion capacitance} \\
F.B. & : C_d \text{ dominates} \\
R.B. & : C_j \text{ dominates} \\
\end{align*} \]
$C_N = \frac{C_{po}}{(1 + \frac{V_{CE}}{V_{bi}})^m}$

[few pF]

$C_{TT} = C_{je} + C_d = C_d$

(base transit time for charge to travel from emitter to collector)

[$\sim 100\ pF$]

$C_s$: collector-substrate capacitor

R.B. junction capacitor
Hybrid-$\Pi$ Equivalent Circuit

\[ \frac{C_{\pi}}{} \]

[Diagram of the hybrid-$\Pi$ equivalent circuit with components labeled.]
Resistance

\( R_b \): silicon resistance from base contact to the edge of emitter \((R_B\) in spic) \([50 - 500 \, \Omega]\)

\( R_c \): silicon resistance from collector contact to the collector-base junction \((R_C\) in spic) \([\sim 100 \, \Omega]\)

\( R_e \): resistance in series with emitter lead \((R_E\) in spic) \([1\sim3 \, \Omega]\)

\( R_m \): reverse-biased diffusion resistance between collector and base
\[ R_m \approx 5\beta R_0 \] (ignored in text in general)
High Frequency MOSFET Transistor Model

\[ C_{gsT} = C_{gs} + C_{gsp} \]
\[ C_{gdT} = C_{gd} + C_{gdP} = C_{gdP} \]
Capacitances:

1. Gate to inversion layer
   \[ C_{gs} \approx C_{gd} \approx \left( \frac{1}{2} \right) WL \cdot C_{ox} \quad \text{Non-sat} \]
   \[ C_{gs} = \frac{2}{3} WL \cdot C_{ox} \quad \text{SAT} \]
   \[ C_{gd} = 0 \quad \text{(inversion layer disappears)} \]

2. Overlap capacitance
   \[ C_{gsp} = C_{gdp} = Cox \cdot \frac{L_D}{W} \quad \text{[overlap in spice]} \]
   \[ \text{[CGSO & CGDO in spice]} \]

3. Junction capacitance
   Drain is R & wrt substrate
   \[ \text{[CBD in spice]} \]
Resistance

1. $R_d$: Drain resistance
   silicon resistance
   $\sim 10 \Omega$ (RD in spiu)

2. $R_s$: Similar to $R_d$ (RS in spiu)