Bipolar Transistor Operating Modes

- **Active Mode:** $V_{ce} > 0.3V$, $V_{be} = 0.7V$
- **Cutoff Mode:** $I_{ce} = 0$, $V_{be} < 0.7V$
- **Saturation:** $V_{ce} = 0.3V$, $V_{be} = 0.7V$
- **Reverse Mode:** $V_{be} < 0.7V$, $V_{bc} = 0.7V$
BJT Flow Chart

Start

1. $I_b > 0$?
   - Y: $V_C > V_E$?
     - Y: $I_c = \beta I_b$?
       - Y: Active
       - N: Reversed
       - N: Saturated
     - N: Cut Off
   - N: Start again

Active
BJT Biasing Example

A transistor with a current source of 20 $\mu$A, a resistor of 1.0 $k\Omega$, and a 5.0V supply voltage.
Load Line Graphical Solution

\[ V = 5.0 - 1000I \]

\[ I_c, \text{ mA} \]

\[ V_{ce}, \text{ V} \]

\[ I_b = 20\, \mu\text{A} \]
TTL NAND Gate

![TTL NAND Gate Diagram]

- $V_{cc}$
- $A$
- $B$
- $4.0 \, k\Omega$
- $1.3 \, k\Omega$
- $130 \, \Omega$
- $\overline{AB}$
CMOS Inverter

\[ Q_1 \quad \bar{A} \]

\[ A \quad Q_2 \]