Lecture 16: Bipolar Junction Transistors (BJTs) I

• Announcements:
  • HW#6 online soon and due Friday two weeks from now via Gradescope
  • Lab#3 for Monday sections next week, but no lab for the other sections
  • By popular demand, it looks like we will hold lab sections next week
  • Midterm 1: Friday, Oct. 5, from 5-6:30 p.m., in 277 Cory
    • Will go through a Midterm Info Sheet today
    • Midterm Info Sheet will be online soon
  • Hopefully, those without access to 125 Cory will soon get access

• Lecture Topics:
  • Midterm Info
    • Bipolar Junction Transistor (BJT)
      — Regions of Operation
      — Cutoff
      — Forward-Active

• Last Time:
  • Finished MOS physics (for now)
Regions of BJT Operation

<table>
<thead>
<tr>
<th>EBJ</th>
<th>CBT</th>
<th>Mode</th>
<th>Note</th>
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</thead>
<tbody>
<tr>
<td>R</td>
<td>R</td>
<td>Cutoff (both diodes off)</td>
<td>Widely used in analog amplifiers</td>
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<tr>
<td>F</td>
<td>R</td>
<td>Forward Active</td>
<td></td>
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<tr>
<td>R</td>
<td>F</td>
<td>Reverse Active</td>
<td></td>
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<tr>
<td>F</td>
<td>F</td>
<td>Saturation</td>
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⇒ Or graphically:

- Cutoff: Both diodes reverse-biased
  - No current flows
  - $i_B = 0$, $i_C = 0$, $i_E = 0$
**BEJ Forward-Biased:**

- Get diffusion current as in diode
- Forward-biasing of a BJT \( \Rightarrow \) three current components:

  1. e⁻'s injected from emitter to base:

     \[
     I_{EB} = -A J_{imb}
     \]

  2. h⁺'s injected from base to emitter:

     \[
     I_{pE} = -A J_{ip}
     \]

  3. Recombination of e⁻'s and h⁺'s in the base

     \[
     I_{RB} \propto e^{(qN_{BE}) / (kT)}
     \]

**i_c = i_{EB} + i_{pE} + i_{RB}**

**i_E = i_{EB} + i_{pE} + i_{RB}**