ECEN325: Electronics
Summer 2018

Bipolar Junction Transistor (BJT)

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Announcements & Reading

• Exam 1 on June 29
• HW4 due July 6
• Razavi Ch4
  • 4.1-4.4, 4.6, 4.7
• Razavi Ch5
BJT Circuit Symbols

- BJT Ts are 3 terminal devices
  - Collector, Base, & Emitter
- 2 complementary BJT devices: NPN & PNP
NPN BJT Device Structure

- BJTs consist of 2 back-to-back junctions (diodes) with a shared middle region
  - np & pn for the NPN transistor
- Doping level varies dramatically with region
PNP BJT Device Structure

- BJTs consist of 2 back-to-back junctions (diodes) with a shared middle region
  - pn & np for the PNP transistor
- Doping level varies dramatically with region
## BJT Modes of Operation

<table>
<thead>
<tr>
<th>Mode</th>
<th>Base-Emitter Junction</th>
<th>Base-Collector Junction</th>
<th>Application</th>
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<tbody>
<tr>
<td>Cutoff</td>
<td>Reverse</td>
<td>Reverse</td>
<td>Digital Logic “Switch Off”</td>
</tr>
<tr>
<td>Saturation</td>
<td>Forward</td>
<td>(Strong) Forward (&gt;0.4V)</td>
<td>Digital Logic “Switch On”</td>
</tr>
<tr>
<td><strong>Active</strong></td>
<td><strong>Forward</strong></td>
<td><strong>Reverse</strong></td>
<td><strong>Analog Amplifier</strong></td>
</tr>
<tr>
<td>Reverse Active</td>
<td>Reverse</td>
<td>Forward</td>
<td>??</td>
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</tbody>
</table>

### Diagrams:
- **Cutoff**: Collector @ 5V, Base @ 5V (±), Emitter @ 5V (±)
- **Saturation**: Collector @ >-0.4V (±), Base @ 0.7V (±), Emitter @ 0V
- **Active**: Collector @ 0.7V (±), Base @ 1V, Emitter @ 5V
- **Reverse Active**: Collector @ 5V (±), Base @ 1V, Emitter @ 5V (±)
• Emitter current $i_E$ consists of injected electrons into the base and injected holes from the base
  • Due to the doping disparity, the electron current is much greater than the hole current

• The electrons injected into the base diffuse across the narrow base region and are swept or “collected” into the collector due to the $V_{CB}$ bias

• The net result is a collector current which is almost equal to the emitter current, and whose values are determined by the $V_{BE}$ bias