# POE2025 Week 9 Diode and BJT Hand in 3

### 1. The Aim

Make knowledge about power Diode and BJT switching behavior more explicit.

This is done by evaluating simulations of power BJT in one of its typical applications where the focus is on some specific datasheet parameters that is important for the application.

The focus areas are:

1. The BJT, Q1 in an inductive switch application with a freewheeling diode, D1. The inductor is simulated with a current source in the simulation setup. For the BJT the ON and OFF switching is simulated with the focus on behavior of the Base-Emitter voltage, VBE, Collector current, IC, and the Collector-Emitter voltage, UCE, over time. For the Diode, D1, the focus is the reverse recovery time trr, the maximum reverse current IRR, charge Qrr and an estimation of the Recovery Softness factor = snappiness factor (**As for Hand-In 2 with the MOSFET**).
   Below in figure 1, there is a test setup for the simulation in LT spice.

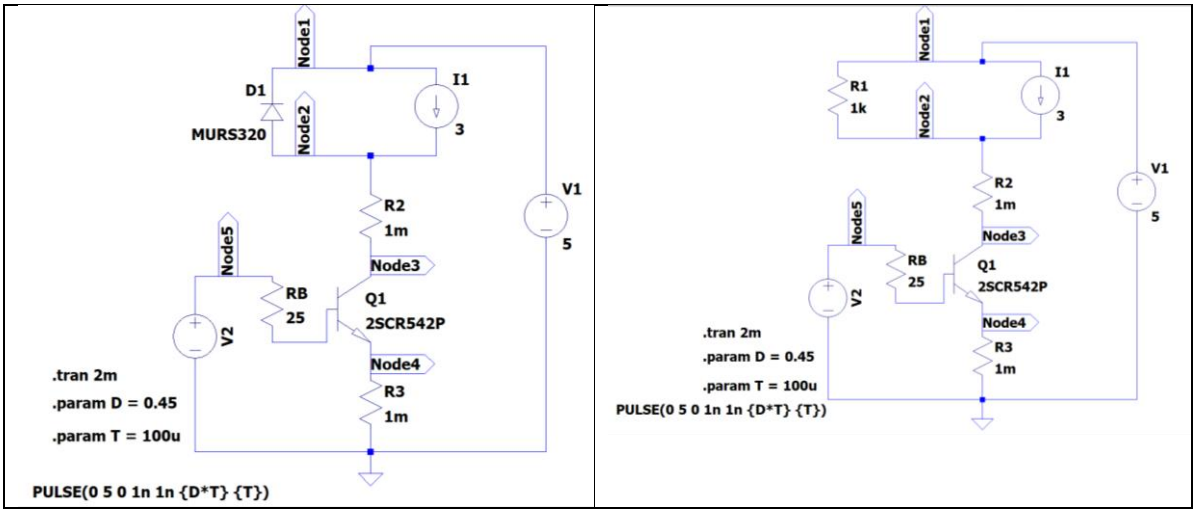


**Figure 1.** The BJT, Q1 and the Freewheeling diode, D1 in a classic switch setup. I1 models an Inductor. R1 models the situation when there is no Freewheeling diode. (Note: an open circuit would make the SPICE math-core calculate too long). RB sets the base current.

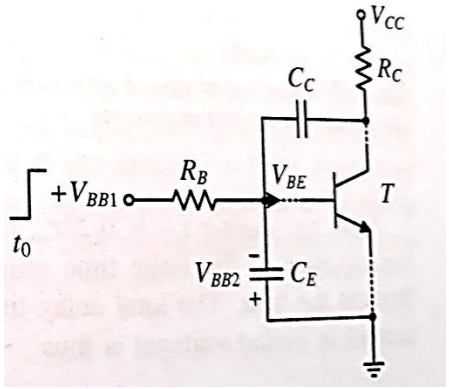


**Figure 2:** The Power BJT model setup in inverter setup (Typical switch with ohmic load).

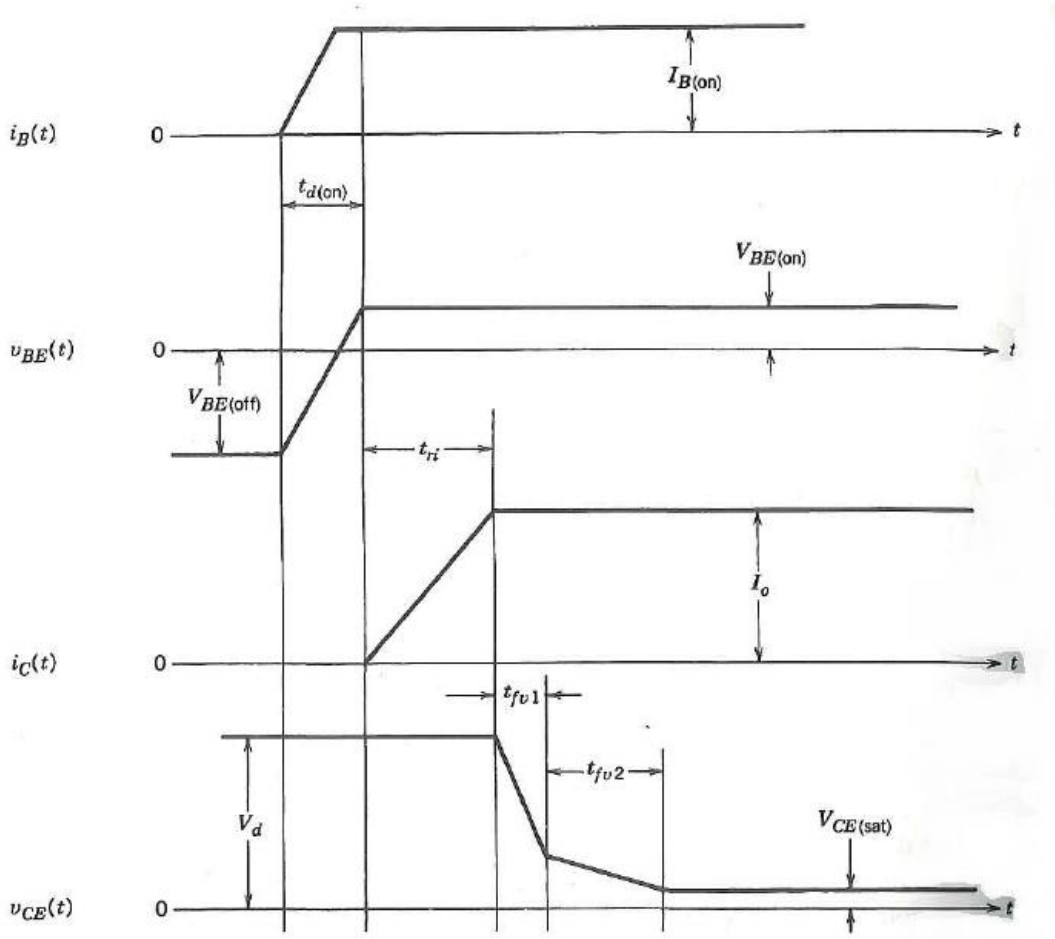


**Figure 3:** The BJT Turn ON times with uncontrolled Base Current and ohmic load.

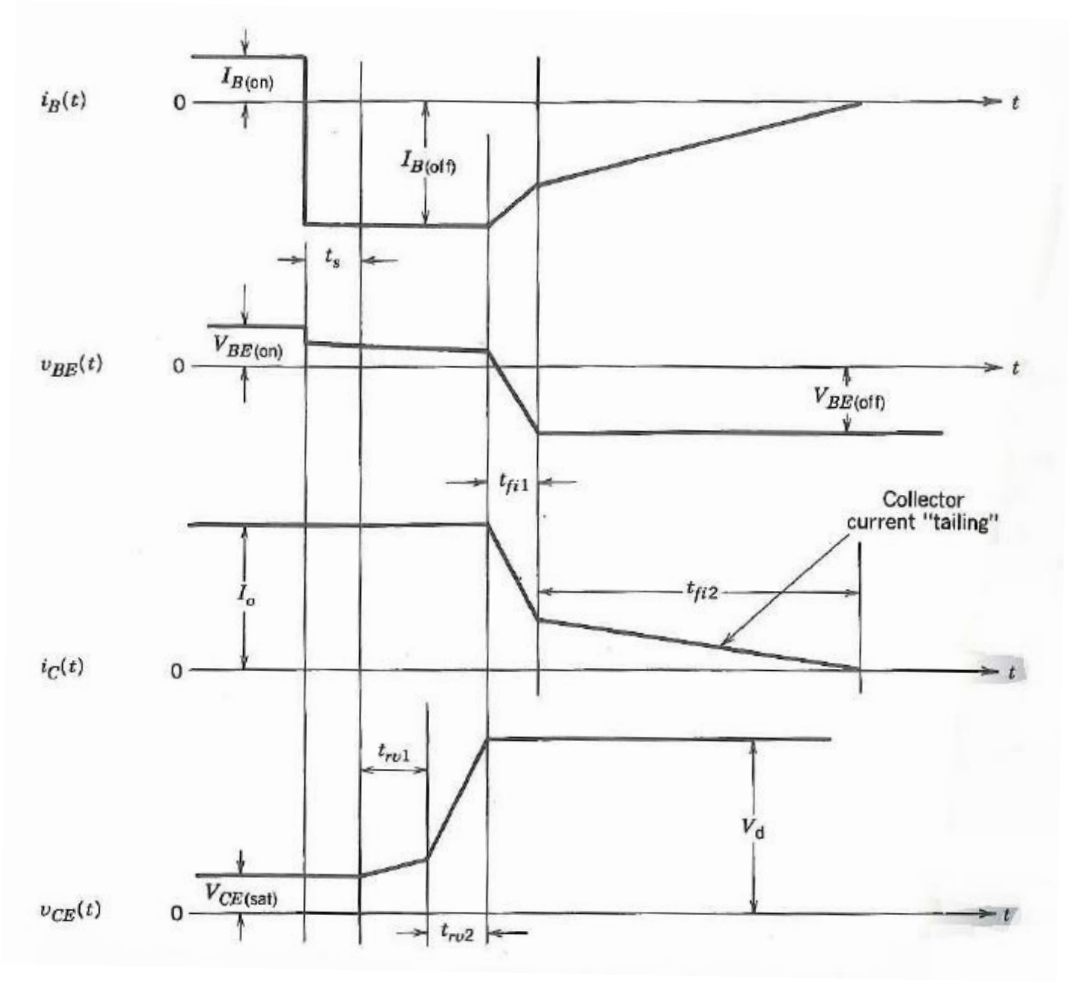


**Figure 4.** Turn-off Waveforms with Uncontrolled Base Current and ohmic load.

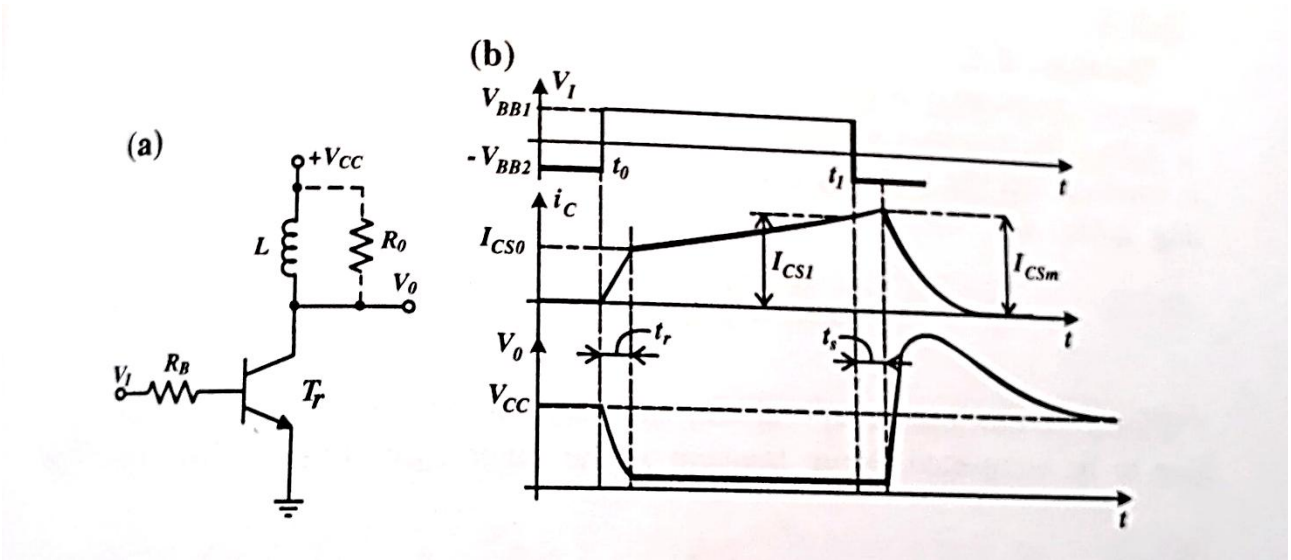


**Figure 5.** Turn-ON/OFF Waveforms with Uncontrolled Base Current and inductive load.

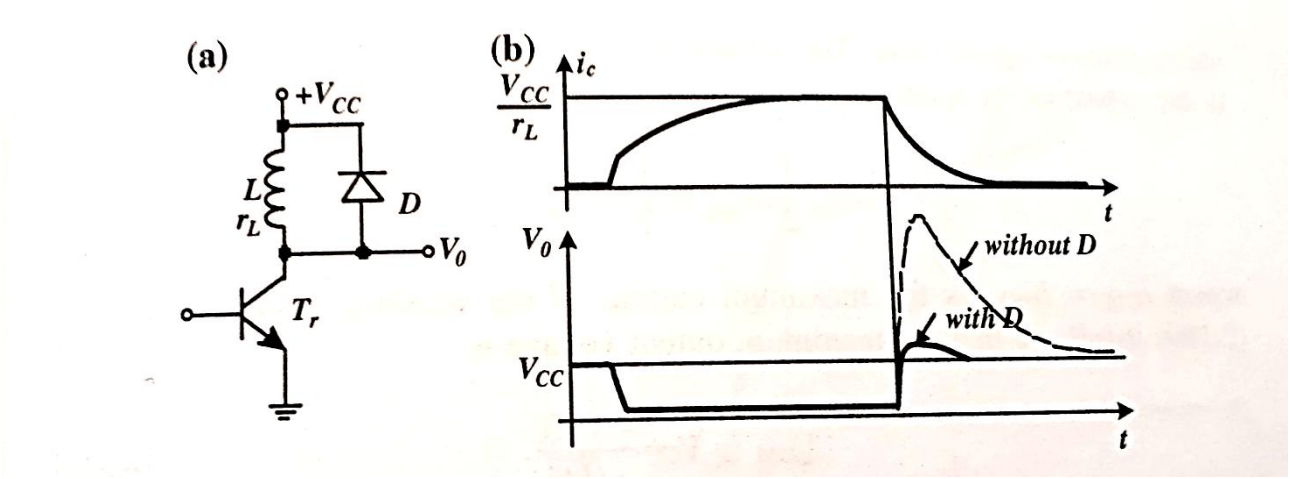


**Figure 6.** Turn-ON/OFF Waveforms with Uncontrolled Base Current and inductive load with Free-wheeling diode.

## Recommended Approach:

1. HINT: Start the sim at the Base-Emitter voltage and current and add then the other graphs for the collector current and voltage.
2. Describe your actual simulation setup and illustrated it with necessary screen dumps with white backgrounds.
3. The Medium Power BJT datasheet used as a reference is 2SCR542PFRA from ROHM Semiconductor. (www.alldatasheet.com).
4. The diode datasheet used as reference is MURS320 from Vishay.
5. Discuss the simulation result to the datasheets and the available literature.
6. **BJT:** Simulate and compare your simulations to the Switching Characteristics in the datasheet for the BJT. Focus on the Rise Time: tr (10%-90% of voltage span) and Fall Time: tf (90%-10% of voltage span) (VBE, VCE and IC). Please note the Datasheet measurement setup and how datasheet define the times. It is typical based on a standard test setup for BJTs in the industry.
7. **DIODE:** For the Diode, D1, the focus is the simulation of the reverse recovery time trr, the maximum reverse current IRR, an estimation of the charge Qrr and an estimation of the snappiness factor (Note: See definition for snappiness in Hand in 2).
8. **Exploration:** Investigate what happens to the BJT Collector-Emitter voltage, when the Freewheeling diode is replaced with a 1kOhm resistor, or the diode is missing. Is the collector-emitter voltage in the simulation over the maximum allowable breakdown voltage given in the datasheet?
9. Consider having the same “report”/”powerpoint” setup as for the MOSFET in Hand-in 2.