Example: Constructing a Diode Small-Signal Model

Recall that one method for constructing a diode PWL model is to specify a single point (i.e., the **bias point**) on the junction diode curve, and then determine the **slope** of the junction diode curve at that point.

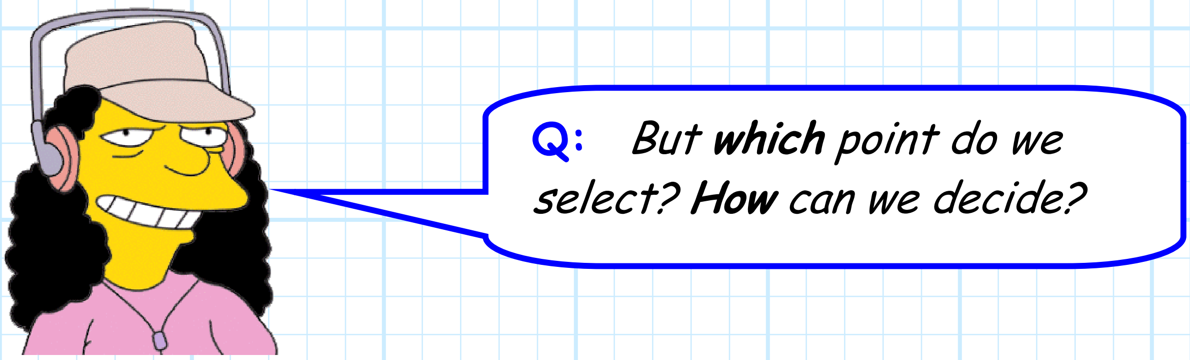
We can then select our **PWL model parameters** r_d and V_{D0} such that the PWL model "line" will **intersect** the specified bias point, and so that the slope of the line will **match** that of the junction diode curve at the bias point.

We call this model the **small-signal** PWL diode model!

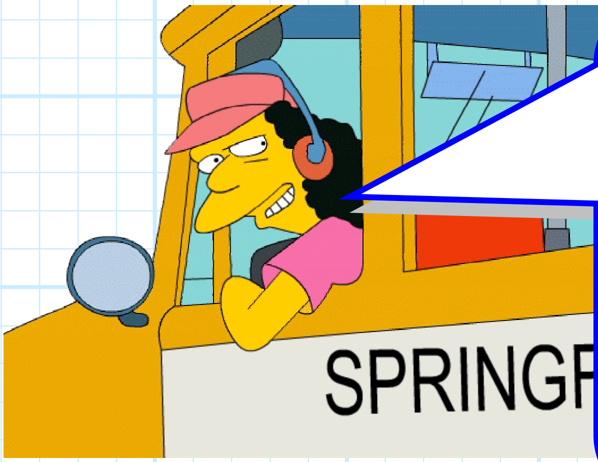
For **example**, say a junction diode with $n=1$ pulls a diode current of $i_D = 10$ mA at a diode voltage of $v_D = 0.6$ V.

→ Let's build a **small-signal PWL model** for this diode!

First, we need to **select a bias point** (I_D, V_D). Recall that this can be any point on the **junction diode curve**.



A: Remember, a PWL model (with a **linear** i_D, v_D relationship) can only "match" the junction diode curve (with an **exponential** i_D, v_D relationship) over a relatively small region. Thus, we want our PWL model to accurately "match" the junction diode curve over the region where the **correct** junction diode solution i_D, v_D actually lies.



Q: *Whoa! How can we do that? We are constructing the PWL model so that we can accurately estimate the **unknown** junction diode values i_D, v_D. But now you say that we must first **know** the solution in order to construct a useful PWL model!*

A: It is of course **true** that if we already know the **exact** value of junction diode i_D and v_D, we might as well **stop working**—we already have the final answer!

However, we do **not** require the **exact** junction diode solution in order construct a useful PWL model. Rather, we need only to have **approximate** knowledge (i.e., a "rough idea").

Often, we can do a **quick analysis** of a circuit to get a rough ideal of the diode current. For example, we can use the **ideal diode model** (or the **CVD model**) to determine an **approximate** value for i_D.

You can then use this approximate **current** value to **select your bias point** (on the junction diode curve). Now **you** can construct an accurate small-signal PWL diode model!

OK, now back to our **example**. Say that **somehow** we know that the actual junction diode current in our circuit is in the **vicinity** of 10 mA. Let's therefore use as our bias point the values that we were **initially** given—values that describe a point **lying** on the **junction diode curve**:

$$I_D = 10 \text{ mA} \qquad V_D = 0.6 \text{ V}$$

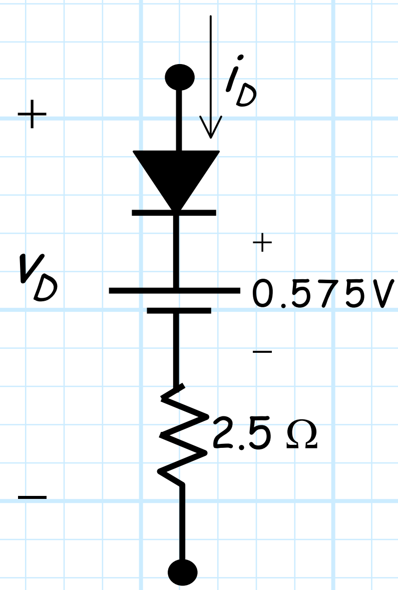
Note that this was the **hardest** part of the whole process! Determining the model parameters is now **straightforward**.

Using the results of a previous handout, we find:

$$r_d = \frac{nV_T}{I_D} = \frac{1(0.025)}{10} = 0.0025 \text{ K} = 2.5 \ \Omega$$

and

$$\begin{aligned} V_{D0} &= V_D - nV_T \\ &= 0.6 - 0.025 \\ &= 0.575 \text{ V} \end{aligned}$$



We're **done**!