Example: Constructing a PWL Model

For a certain junction diode, we **know** that:

$$i_D = 10 \text{ mA} \quad \text{when} \quad v_D = 0.7 \text{ V}$$

and

$$i_D = 1 \text{ mA} \quad \text{when} \quad v_D = 0.6 \text{ V}$$

Say we wish to **construct a PWL model** that will approximate this junction diode behavior for diode currents from, say, approximately 1 mA to approximately 10 mA.

Recall that the resulting model will relate diode voltage V_D to diode current i_D as a **line** of the form:

$$i_D = \left(\frac{1}{r_d}\right) v_D - \left(\frac{V_{D0}}{r_d}\right)$$

We therefore need to determine the values of V_{D0} and r_d such that this PWL model "line" will **intersect** the two points i_{D1} =1.0, v_{D1}=0.6 and i_{D2}=10.0, v_{D2}=0.7.

The **slope** of this line must therefore be:

$$m = \frac{i_{D2} - i_{D1}}{v_{D2} - v_{D1}} =$$

Thus our PWL model **resistor value** r_d must be:

$$r_d = \frac{1}{m} =$$

Or in other words, $r_d = 11.1\,\Omega$.

> **Q:** *Wow! That's a **very small** resistance value. Are you **sure** we calculated r_d correctly?*
>
> **A:** Typically, we find that the resistor value in the PWL model **is** small. In fact, it is frequently **less than 1** Ω when we attempt to match the junction diode curve in a "high" current region (e.g., from i_D =50 mA to i_D=500 mA).

Now that we have determined r_d, we can insert **either** point into the model **line equation** and solve for V_{D0}. For example, the equations:

$$i_{D1} = \left(\frac{1}{r_d}\right) v_{D1} - \left(\frac{V_{D0}}{r_d}\right) \quad \text{or} \quad i_{D2} = \left(\frac{1}{r_d}\right) v_{D2} - \left(\frac{V_{D0}}{r_d}\right)$$

become either:

$$V_{D0} = v_{D1} - i_{D1}\, r_d$$
$$=$$
$$=$$

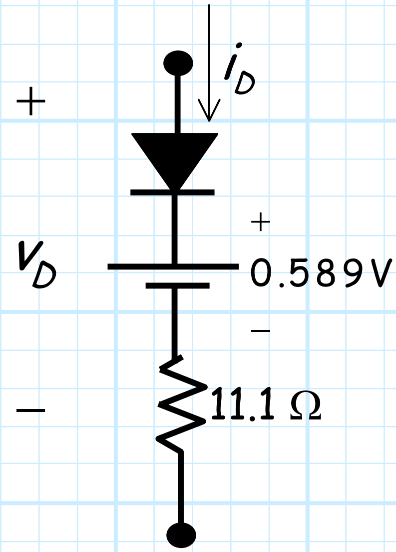
or

$$V_{D0} = v_{D2} - i_{D2}\, r_d$$
$$=$$
$$=$$

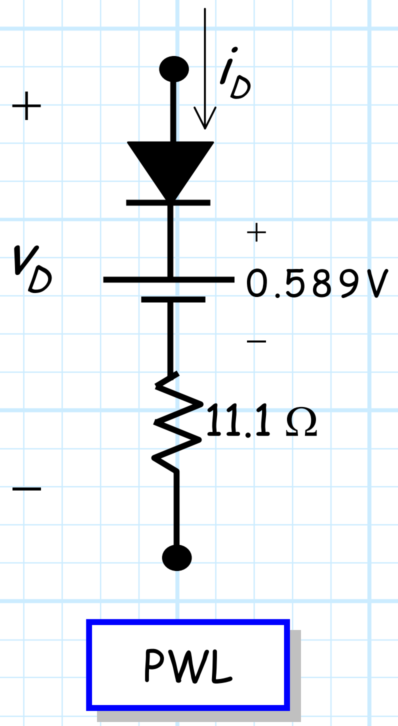
In other words, we can use **either** point to determine V_{D0}.

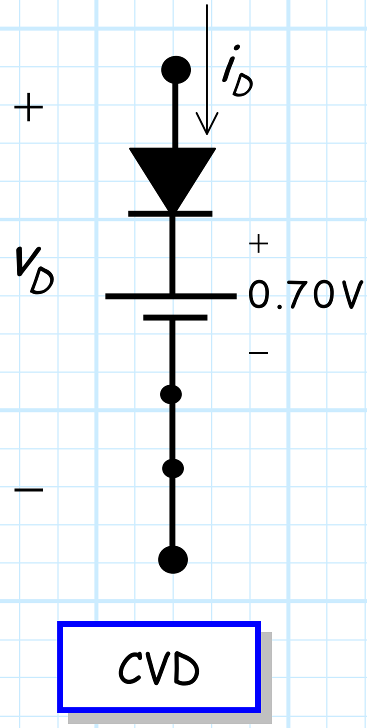
Our **PWL model** is therefore:

$$i_D = \begin{cases} 0 & \text{for} \quad v_D < 0.589 \text{ V} \\ \dfrac{v_D}{0.0111} - \dfrac{0.589}{0.0111} \text{ mA} & \text{for} \quad v_D > 0.589 \text{ V} \end{cases}$$



Now, **compare** this PWL model to the CVD model:





Note that the CVD model can be viewed as a PWL model with V_{D0}= 0.7 V and r_d= 0.0. **Compare** those values with our model (V_{D0}= 0.589 V and r_d= 11.1Ω)—**not** much difference!

Thus, the PWL model is **not** a radical departure from the CVD model (typically V_{D0} is close to 0.7 V and r_d is **very** small). Instead, the PWL can be view as **slight improvement** of the CVD model.