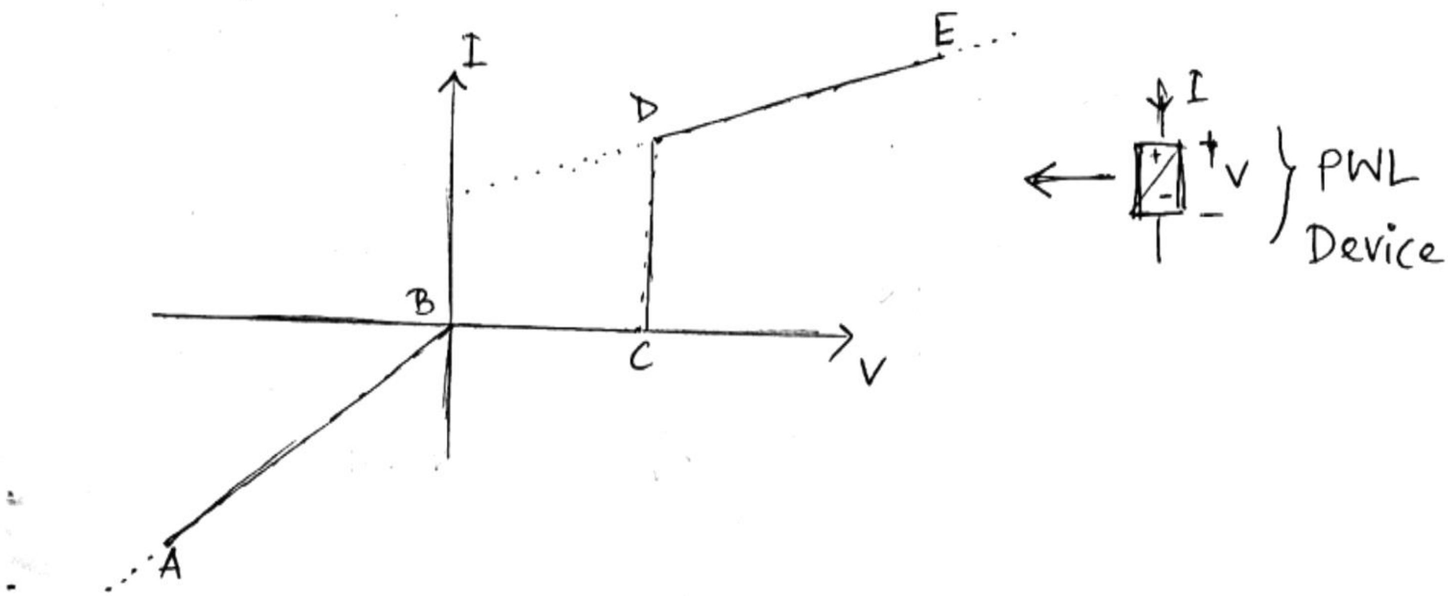
Piece-Wise Linear Devices

These are a subset of non-linear devices, whose I-V characteristics cannot be drawn using a single straight line, but, <u>can</u> be drawn using <u>multiple</u> straight lines.

An example is shown below:



Here, the I-V chars ~~ha~~ can be drawn using 4 straight lines. In the 4 different regions, the PWL device has a different state.

In AB, it acts like a resistor.
(linear IV passing through the origin).

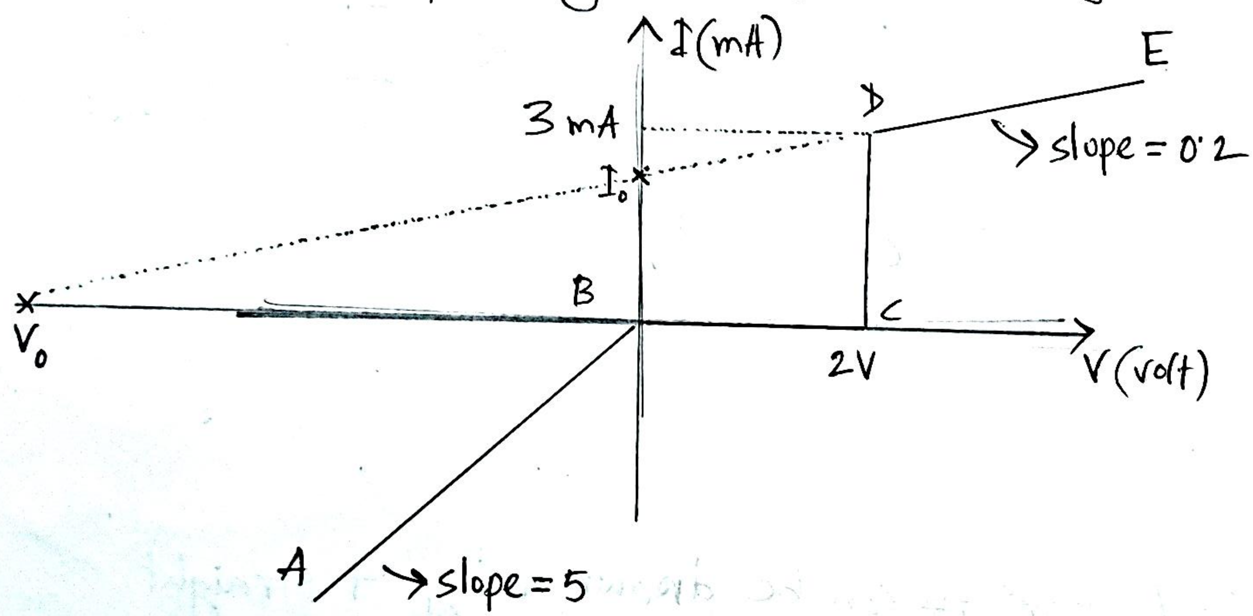
In BC, it acts like an open-circuit.
(straight line along V-axis)

In CD, it acts like a voltage source.
(straight line parallel to I-axis)

In DE, it can be modelled either as a voltage source with a series resistance, or, a current source with a parallel resistance. (linear IV <u>not</u> passing through the origin).

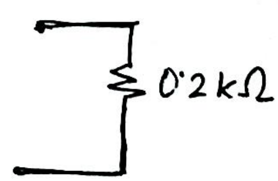
We can find the device parameters from the IV if the relevant data are given.

Consider the following data given in the graph.



In the region AB (i.e, if $V \leqslant 0$ Volt), the device acts like a resistor. The value of resistance is,

$$R = \frac{1}{\text{slope}} = \frac{1}{5} = 0 \cdot 2\ k\Omega.$$

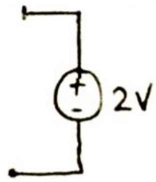


[Unit is kΩ because I is given in mA, and V in volts.

$\frac{\text{Volt}}{\text{mA}}$ = kilo-ohm]

In BC, ~~[illegible]~~ (i.e, if $0 \leq V \leq 2V$), the device is an open-circuit.

In CD, (i.e, if $V = 2V$, and $0 \leq I \leq 3mA$), the device acts like a voltage source. The value of the voltage-source is $V_o = 2V$.



In DE, (i.e, if $V \geq 2V$), the device can be modelled either as V.S. + R_S, or, C.S. + R_P.

If it is modelled as V.S. + R_S (Voltage source + series resistance), the value of V.S. will be the intersection of <u>extension</u> of DE with the <u>voltage axis</u>.

If it is modelled as C.S. + R_P (current source + parallel resistance), the value of C.S. will be the intersection of the extension of DE with the <u>current axis</u>.

Suppose, we choose to model it as C.S. + R_P.

Then, $R_P = \frac{1}{\text{slope}} = \frac{1}{0.2} = 5k\Omega$.

Next, write the eq^n of DE. It will be,

$$Y = mx + C \Rightarrow Y = 0.2x + C \quad [\because m = \text{slope} = 0.2].$$

Find the value of c by putting the co-ordinates of point D,

$D \equiv (2, 3)$.

$$\therefore 3 = 0.2 \times 2 + C \Rightarrow C = 2.6.$$

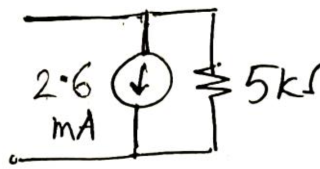
$\therefore$ Eq^n of DE: $y = 0.2x + 2.6$.

Intersection with current axis will be: (put, $V=0$, i.e, $x=0$).

$$y = 0.2 \times 0 + 2.6 = 2.6$$

$\therefore I_0 = 2.6$ mA

So, the C.S. + R_p model is this:



[Direction of C.S. is downwards, because, I_0 is positive].

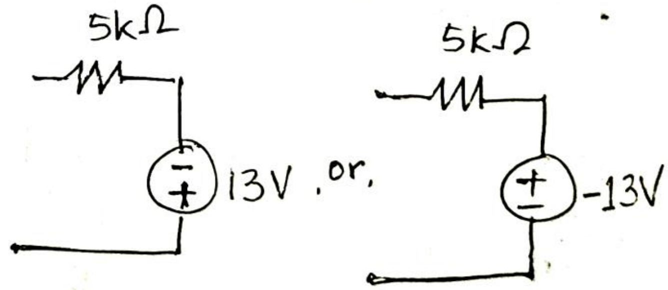
Similarly intersection with voltage axis will be: (put $I=0$, i.e, $y=0$)

$$0 = 0.2x + 2.6$$

$$\Rightarrow x = -\frac{2.6}{0.2} = -13$$

$\therefore V_0 = -13$ V

So, the V.S. + R_s model is this:



[Polarity of V.S. is reversed because, V_0 is negative]