## Solution Test - 1

Here we assume that both the current and voltage have both a **DC** and **small-signal** component:

$$i = I_{DC} + i_{ss} \qquad \text{and} \qquad v = V_{DC} + v_{ss}$$

Now, since the DC voltage across the device is $V_{DC} = 3.0$, we get:

$$i = I_{DC} + i_{ss} \qquad \text{and} \qquad v = 3.0 + v_{ss}$$

In other words, the device voltage $v$ is always **very close** to 3.0 volts!

Applying a **Taylor's series** expansion around $V_{DC} = 3.0$, we find:

$$\begin{aligned} i &\cong \left(4\,v + v^2\right)\Big|_{v=3} + \frac{\partial\left(4\,v + v^2\right)}{\partial v}\Bigg|_{v=3} v_{ss} \\ &= \left(4\,(3) + 3^2\right) + \left(4 + 2v\right)\Big|_{v=3} v_{ss} \\ &= 21 + \left(4 + (2)3\right) v_{ss} \\ &= 21 + 10\,v_{ss} \end{aligned}$$

Since $i = I_{DC} + i_{ss}$, we can equate terms (DC and small-signal) and conclude:

$$I_{DC} = 21\ mA \qquad \text{and} \qquad i_{ss} = 10\,v_{ss}\quad mA$$

**a)** Thus, the **small-signal** resistance $r_{ss}$ of this device is:

$$r_{ss} = \frac{v_{ss}}{i_{ss}} = \frac{v_{ss}}{10\,v_{ss}} = \frac{1}{10} = 0.1K = \underline{\underline{100\Omega}}$$

**b)** If:

$$i_{ss}\ t = 0.2 \cos \omega t \quad mA$$

Then:

$$v_{ss}(t) = r_{ss}\, i_{ss}(t) = (0.1)\, 0.2 \cos \omega t = \underline{\underline{0.02 \cos \omega t \quad V}}$$