DC and Small-Signal Components

Note that we have used **DC** sources in all of our example circuits thus far. We have done this just to **simplify** the analysis—generally speaking, realistic (i.e., useful) junction diode circuits will have sources that are **time-varying**!

The result will be voltages and currents in the circuit that will **likewise vary with time** (e.g., $i(t)$ and $v(t)$). For example, we can express the forward bias junction diode equation as:

$$i_D(t) = I_s e^{v_D(t)/nV_T}$$

Although source voltages $v_S(t)$ or currents $i_S(t)$ can be **any** general function of time, we will find that often, in realistic and useful electronic circuits, that the source can be decomposed into **two** separate components—the **DC component** V_S, and the **small-signal component** $v_s(t)$. I.E.:

$$v_S(t) = V_S + v_s(t)$$

Let's look at each of these components individually:

* The **DC component** V_S is exactly what you would expect—the DC component of source $v_S(t)$! Note this DC value is **not** a function of time (otherwise it would not be DC!) and therefore is expressed as a **constant** (e.g., $V_S = 12.3\,V$).

Mathematically, this value is the **time-averaged** value of $v_S(t)$:

$$V_S = \frac{1}{T}\int_0^T v_S(t)\,dt$$

where T is the **time duration** of function $v_S(t)$.

* As the notation indicates, the **small-signal component** $v_s(t)$ **is** a function of time! Moreover, we can see that this signal is an ***AC* signal**, that is, its time-averaged value is **zero**! I.E.:

$$\frac{1}{T}\int_0^T v_s(t)\,dt = 0$$

This signal $v_s(t)$ is also referred to as the **small-signal component**.

* The **total** signal $v_S(t)$ is the **sum** of the DC and small signal components. Therefore, it is **neither** a DC nor an AC signal!

Pay attention to the **notation** we have used here. We will use this notation for the remainder of the course!

* **DC values** are denoted as **upper-case** variables (e.g., V_S, I_R, or V_D).

* **Time-varying** signals are denoted as **lower-case** variables (e.g., $v_S(t), v_r(t), i_D(t)$).

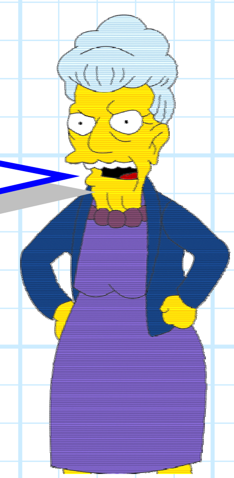
Also,

* ***AC* signals** (i.e., zero time average) are denoted with **lower-case subscripts** (e.g., $v_s(t), v_d(t), i_r(t)$).

* Signals that are **not *AC*** (i.e., they have a non-zero DC component!) are denoted with **upper-case subscripts** (e.g., $v_S(t)$, I_D, $i_R(t)$, V_D).

Note we should **never** use variables of the form V_i, I_e, V_b. Do **you** see why??

Q: *You say that we will often find sources with **both** components—a DC and small-signal component. **Why** is that? What is the significance or physical reason for each component?*



A1: First, the **DC component** is typically just a DC **bias**. It is a **known** value, selected and determined by the design engineer. It carries or relates **no** information—the only reason it exists is to make the electronic devices work the way we want!

A2: Conversely, the **small signal component** is typically **unknown**! It is the signal that we are often attempting to **process** in some manner (e.g., amplify, filter, integrate). The signal itself represents **information** such as audio, video, or data.

Sometimes, however, this small, AC, unknown signal represents not information—but **noise**! Noise is a **random**, unknown signal that in fact masks and **corrupts** information. Our job as designers is to **suppress** it, or otherwise minimize it deleterious effects.

* This noise may be changing **very rapidly** with time (e.g., MHz), or may be changing **very slowly** (e.g., mHz).

* Rapidly changing noise is generally "**thermal noise**", whereas slowly varying noise is typically due to slowly varying environmental conditions, such as **temperature**.

Note that in addition to (or perhaps because of) the source voltage $v_S(t)$ having both a DC bias and small-signal component, **all the currents and voltages** (e.g., $i_R(t)$, $v_D(t)$) within our circuits will likewise have **both** a DC bias and small-signal component!

For example, the junction **diode voltage** might have the form:

$$v_D(t) = 0.66 + 0.001\cos\omega t$$

It is hopefully evident that:

$$V_D = 0.66\,V$$

$$v_d(t) = 0.001\cos\omega t$$