Two-port networks

As you can imagine, majority of components in electronic circuits are two-port networks. For example, in a tape recorder, a large number of two-port networks exists between the source (tape head) and the load (speakers). They amplify the signal, filter out the unwanted noise, and process the signal. We study several two-port networks in 60L. As we noted in the previous page, we can design and analyze these two-port networks using a simple model for the previous stages and a load impedance for later stages of the system as is shown below.

Consider the two-port network below. It "communicates" with the outside world (rest of the circuit) through 4 parameters: $V_i$, $I_i$, $V_o$, and $I_o$. If we solve the two-port network circuit once and find the relationship between these four parameters, we do not need to do that again. While any linear two-port network can be reduced to a combination of four elements (see your circuit theory textbook), it is customary to use the following parameters to describe the behavior of a two-port network.

- **Voltage transfer function**, $H_v(j\omega) = \frac{V_o}{V_i}$
- **Current transfer function**, $H_i(j\omega) = -\frac{I_o}{I_i}$
- **Equivalent input impedance**, $Z_i(j\omega) = \frac{V_i}{I_i}$
- **Equivalent output impedance**, $Z_o(j\omega) = \frac{V_o}{I_o}$

The equivalent output impedance as defined above is the equivalent Thevenin impedance of a two-terminal network consisting of our 2-port network, $Z_s$, and $V_s$.

**What are $Z_L$ and $Z_s$:** Consider a circuit in which our two-port network above is the “nth” two-port network (see figure in the previous page). In this case, the output voltage of “n-1” two-port network is the same as the input voltage of our “nth” two port network: $V_o|_{n-1} = V_i|_n$ and the output voltage of our “nth” two-port network is the input voltage to the “(n+1)th” two-port network: $V_o|_n = V_i|_{n+1}$ (with the similar relationship between the currents). The transfer function definitions above indicate that $Z_L$ is actually the input impedance of “(n+1)th” two-port network (next stage) and $Z_s$ is the output impedance of “(n-1)th” two-port network (previous stage).

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It is obvious from the definitions of transfer functions above that they depend on the values of $Z_L$ and $Z_s$. This means that when a two-port network is placed in a circuit, the output impedance of the previous stage ($Z_s = Z_i|_{n-1}$) and the input impedance of the next stage ($Z_L = Z_i|_{n+1}$) affect the two-port network transfer functions.

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