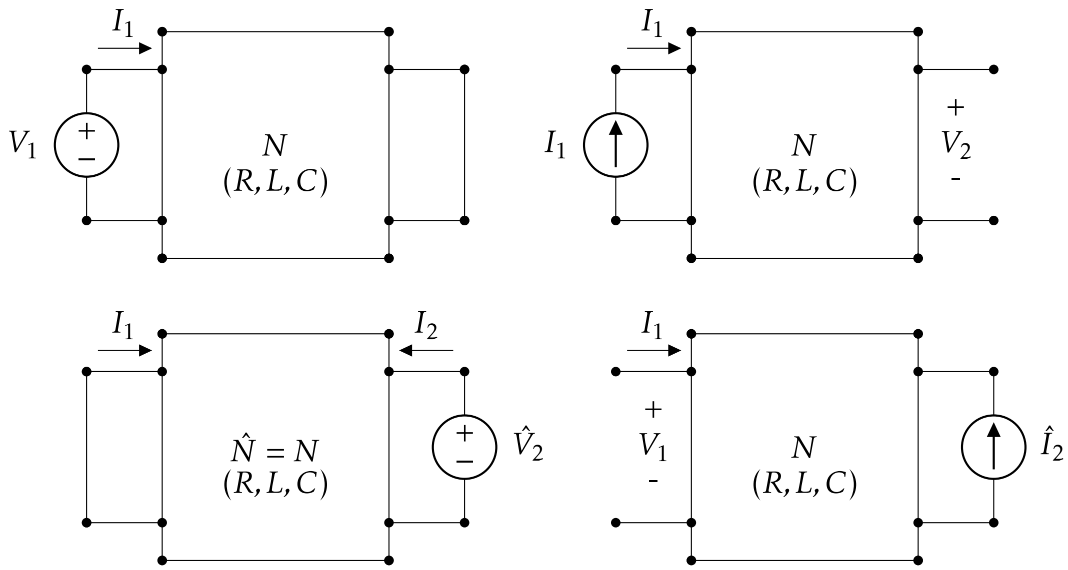
Electric Circuits and Networks **26-09-2018**

Lecture 23: Tellegens theorem and reciprocity - continued

Lecturer: Dr. Vinita Vasudevan *Scribe: Shashank Shekhar*



$$\sum_{k=1}^{b}\left(\hat{v}_k i_k - v_k \hat{i}_k\right) = 0$$

The above statement is known as "Tellegen's Theorem" and valid in both domains t and s.

If we have a network consist of only R, L, C (*i.e.* bilateral element) then the contribution of all internal branches is zero. If the network has L and C also, it is more useful to apply it in the s domain.

Let $k = 1$ represents the branch at port 1 and $k = b$ represents the branch at port 2. All other branches represents the internal branches. So we have

$$\sum_{k=2}^{b-1}\left(\hat{v}_k i_k - v_k \hat{i}_k\right) + \left(\hat{v}_1 i_1 - v_1 \hat{i}_1\right) + \left(\hat{v}_b i_b - v_b \hat{i}_b\right) = 0$$

We Have

$$\sum_{k=2}^{b-1}\left(\hat{v}_k i_k - v_k \hat{i}_k\right) = 0$$

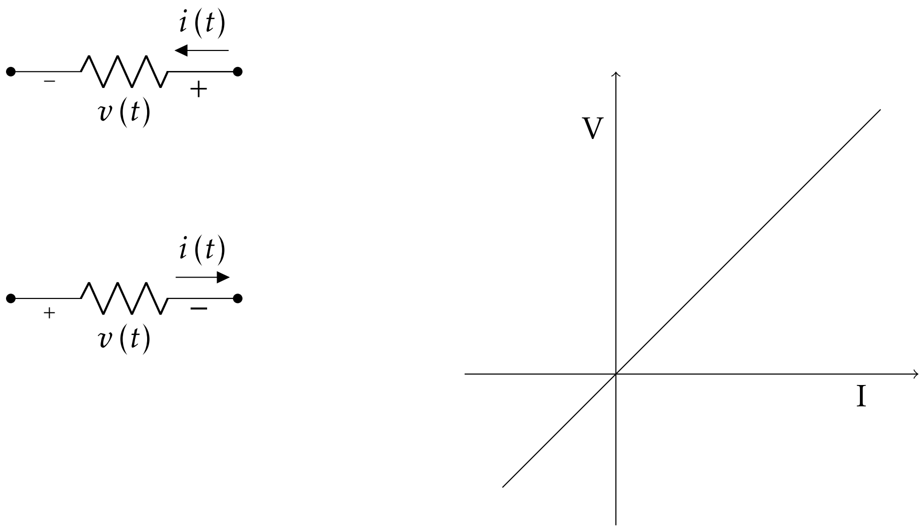
From now onwards we will represent subscript 1 for port one and subscript 2 for port two and we will apply Tellegens theorem in the s domain.

$$\hat{V}_2(s) I_2(s) = V_1(s) \hat{I}_1(s)$$

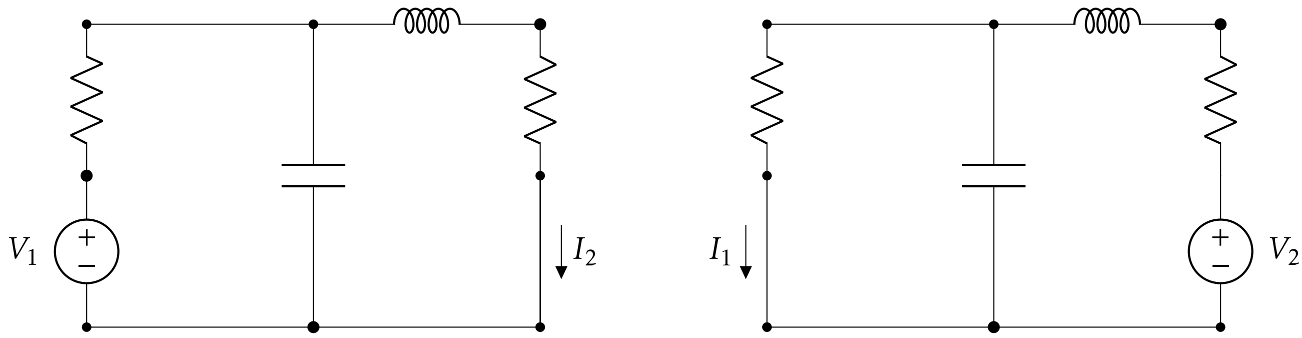
$$\frac{\hat{I}_1(s)}{\hat{V}_2(s)} = Y_{12}(s) = \frac{I_2(s)}{V_1(s)} = Y_{21}(s)$$

This is the condition for reciprocal networks.

The resistor is a bilateral element



Another example of reciprocity.



Using Tellegen's theorem we have

$$\frac{I_2}{V_1} = \frac{I_1}{V_2}$$

i.e., if we change the position of the voltage source, the "transfer functions" remain the same.