9.4.4 ROLE REVERSAL*

In each example in this section, a single capacitor or inductor was driven by a source. When that element was driven by a current source its branch current was imposed, and its branch voltage evolved in response. Alternatively, when the element was driven by a voltage source, its branch voltage was imposed, and its branch current evolved in response. However, because the branch variables of a capacitor are self-consistently related by Equations 9.9 and 9.12, their roles as the sourced and the responding branch variable may be reversed. Similarly, because the branch variables of an inductor are related by Equations 9.28 and 9.30, their roles may also be reversed. This allows us to use one circuit response to derive its converse. Specifically, we will derive the circuit responses to impulse inputs using the role reversal argument.

As an example of role reversal consider the circuit shown in Figure 9.32 with the source voltage V given by Equation 9.80. The current i that circulates through its source and capacitor in response to the step in source voltage is the current impulse given by Equation 9.86. Now suppose instead that it is the current i in Equation 9.86 that is imposed by a source, as in Figure 9.31 with $I \equiv i$. What would be the voltage response v across the source and capacitor? The answer is that it would be V from Equation 9.80 so that $v = V$. This can be verified by substituting i in Equation 9.86 for I in Equation 9.63 and carrying out the indicated integration with the help of Equation 9.82 to derive v. Thus the current and voltage in Equations 9.86 and 9.80 are a self-consistent pair of branch variables for a capacitor. They can be either the source and response, or the response and the source. In this way we are able to find the circuit response to a current impulse from the circuit response to a voltage step.

In the same way, we can use Equations 9.90 and 9.91, which apply to the circuit shown in Figure 9.34, to determine i in Figure 9.33 for the case in which V is an impulse. For example, suppose that the voltage v in Equation 9.91 is imposed by the source in Figure 9.33 with $V \equiv v$. What would be the current response i through the source and inductor? The answer is that it would be I from Equation 9.90 so that $i = I$. This can be verified by substituting v in Equation 9.91 for V in Equation 9.65 and carrying out the indicated integration with the help of Equation 9.82 to derive i. Thus the current and voltage in Equations 9.90 and 9.91 are a self-consistent pair of branch variables for an inductor. They can be either the source and response, or the response and the source. In this way we are able to find the circuit response to a voltage impulse from the circuit response to a current step.