DC Source Conversions Proof

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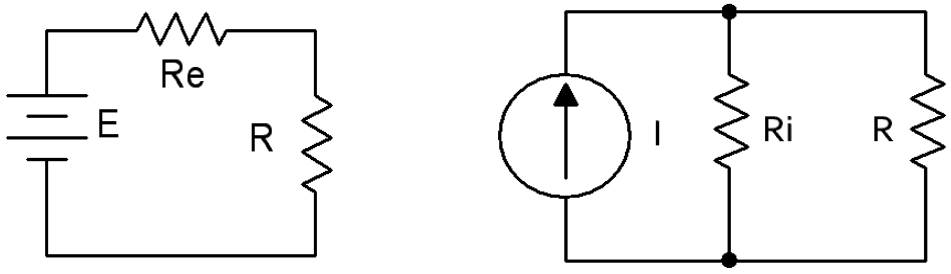
For any realistic voltage source comprised of an ideal voltage source with series internal resistance there exists an equivalent current source consisting of an ideal current source with parallel internal resistance. The converse is also true. By *equivalent* we mean that both sources will produce the same current and voltage for any identical load.

Consider a general voltage source and current source:



For equivalence, the load currents must be identical for both circuits given any value of load R. (Note that if the currents are the same then the voltages must also be the same due to Ohm's Law).

For the first circuit, $I_L=E/(R_e+R)$ and for the second circuit, $I_L=I\ R_i/(R_i+R)$

Therefore $E/(R_e+R)$ must equal $I\ R_i/(R_i+R)$ **This will be true when $E = I\ R_i$ and $R_e = R_i$**

To simplify, as R_i and R_e must be the same value, we shall refer to them both as R_s (*s* for *s*ource). So, given a voltage source, the equivalent current source value is E/R_s. Note that this is the maximum case of load current for the voltage source because it represents a shorted load (i.e., all of E drops across R_s). As such it would be nonsensical to use a current source that was larger or smaller than this value because it also represents the shorted load case for the current source (i.e., the full value of the current source, all of which goes to the load). In similar fashion, given a current source, the equivalent voltage source value is $I\ R_s$ This represents the maximum case for voltage (i.e., open load).

So, as an example, a 10 V source with 2k series internal resistance is equivalent to a current source of 5 mA with a parallel internal resistance of 2k. No matter what value of load resistance is chosen, both circuits will yield the same load current and voltage.