SIMPLIS Nonlinear Block (NLB)

The SIMPLIS Nonlinear Block (NLB) components are originally developed as primitive components in SIMPLIS to support the modeling of PFC controllers. When the schematic is set to support the SIMPLIS simulator, these components are available by the following sequence of clicks in the drop-down menus:

Place | SIMPLIS Primitives | Non-linear Block

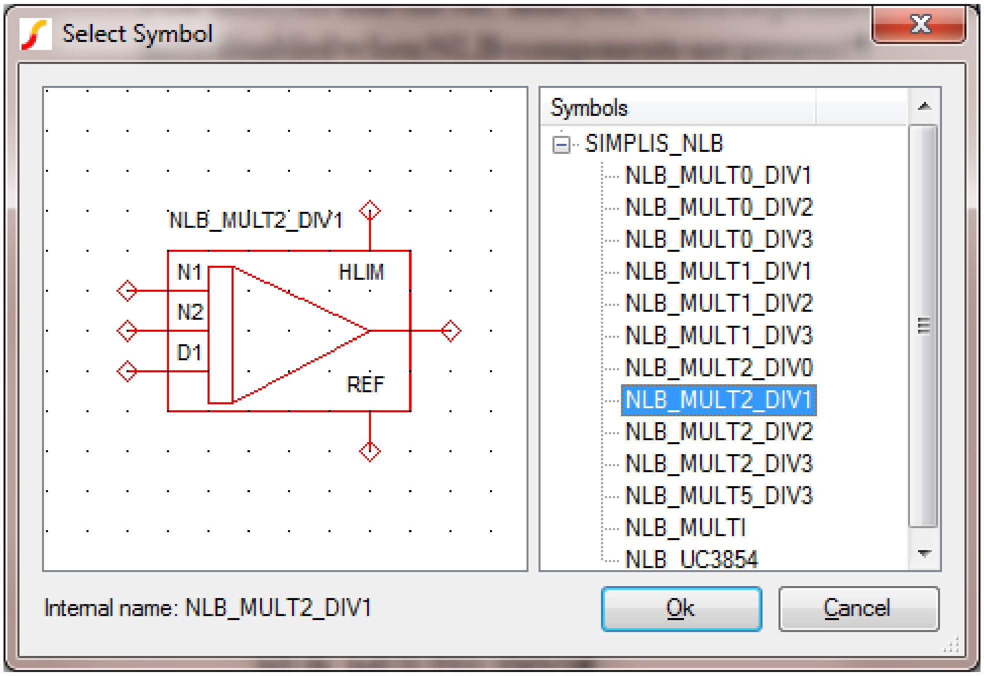
The NLB components are not intended for general-purpose nonlinear modeling. In addition, POP and AC analyses are disabled when a schematic contains at least one NLB component. The modeling and the equations behind the scene for the NLB components are not compatible with the POP analysis. Hence the POP analysis and the AC analysis, which depends on the successful conclusion of the POP analysis, are both disabled when NLB components are present.

The available choices of NLB components are:

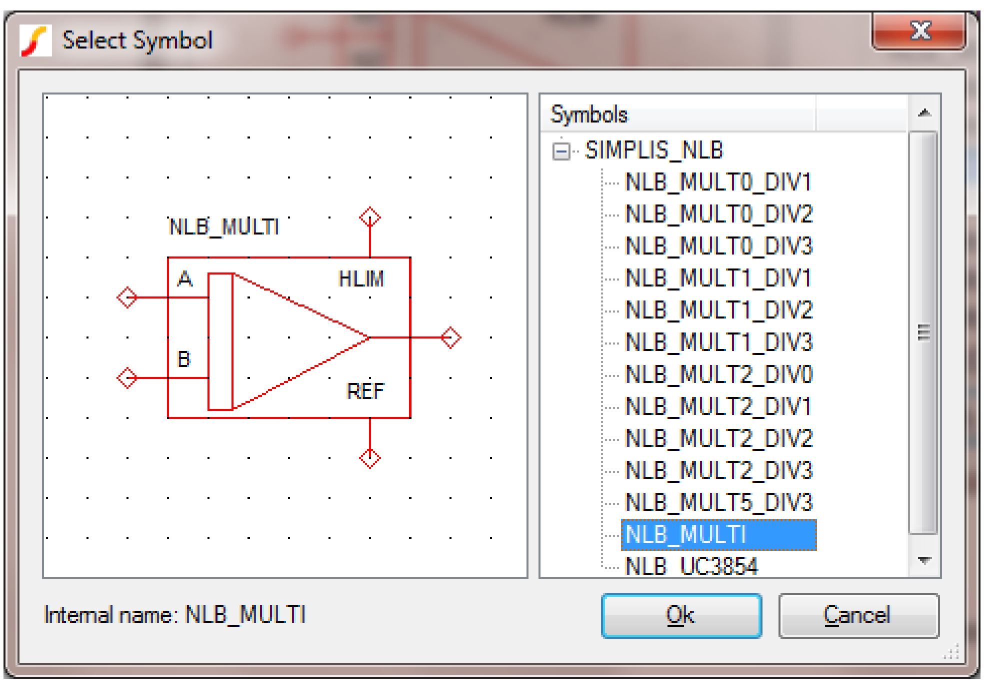
NLB_MULTI0_DIV1
NLB_MULTI0_DIV1
NLB_MULTI0_DIV2
NLB_MULTI0_DIV3
NLB_MULTI1_DIV1
NLB_MULTI1_DIV2
NLB_MULTI1_DIV3
NLB_MULTI2_DIV0
NLB_MULTI2_DIV1
NLB_MULTI2_DIV2
NLB_MULTI2_DIV3
NLB_MULTI5_DIV3
NLB_MULTI
NLB_UC3854

NLB_MULTIx_DIVy means the output of the particular component is normally equal to the product of x number of inputs in the numerator divided by the product of y number of inputs in the denominator.

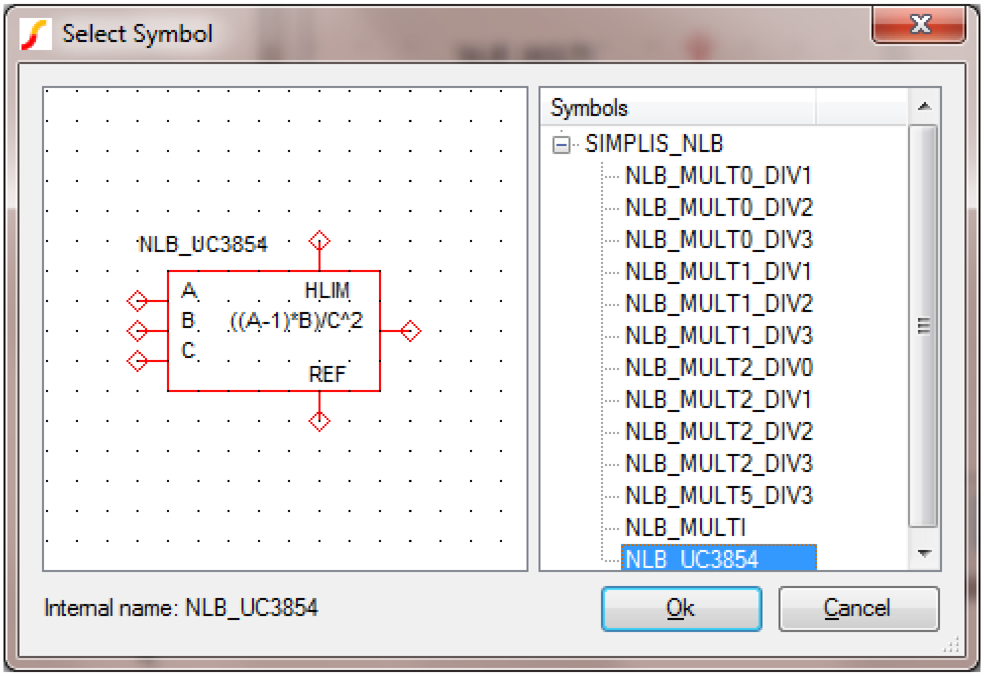
For example, the output of the NLB_MULTI2_DIV1 component is normally equal to the multiplication of two inputs N1 and N2 divided by one input D1. N stands for numerator and D stands for denominator.



The output of the NLB_MULTI component is normally equal to the multiplication of its two inputs A and B:



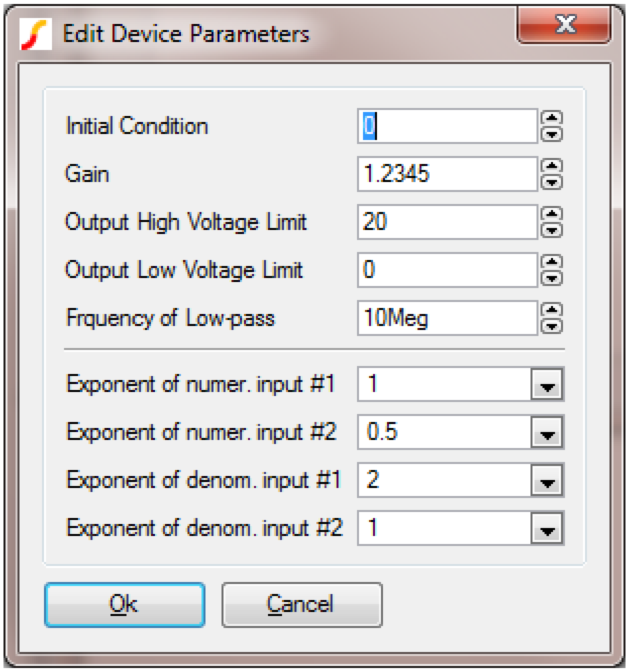
The NLB_UC3854 component models the nonlinear function in the UC3854.



All NLB components share the following characteristics:

1. Each component has a reference pin, named REF.
2. There is a resistive input impedance of 10 G ohms between each input pin and the reference pin and there is a resistive output impedance of 50 ohms between the output pin and the reference pin.
3. All input signals are defined as the differential voltages of the input pins with respect to the reference pin. The output signal is defined as the differential voltage of the output pin with respect to the reference pin.
4. The maximum value of the output is limited to the lower of the following two values:
   a. The differential voltage of the HLIM pin with respect to the reference pin.
   b. The value set to the “Output High Voltage Limit” in the GUI dialog.
5. The minimum value of the output is set to the value entered for “Output Low Voltage Limit” in the GUI dialog. This value cannot be negative. Hence, the outputs of all NLB components are restricted to non-negative values.
6. There is a GAIN factor.
7. There is a low-pass filter placed in the output stage of each NLB component. Hence, instantaneous jumps in the input signals will not cause an instantaneous jump in the output voltage.

In addition, the NLB_MULTIx_DIVy components allow each input signal to be raised to the power of 0.5, 1, 1.5, 2, 2.5, and 3 in the computation of the output. For example, if an NLB_MULTI2_DIV2 component is set to have parameters represented by the following:



then the output of component, when not limited, is equal to

$$\frac{1.2345\, v_{N1}\sqrt{v_{N2}}}{v_{D1}^{2}\, v_{D2}}$$

where v_{N1} and v_{N2} are the voltage of the “numerator” input pins N1 and N2 with respect to the reference pin, respectively, and v_{D1} and v_{D2} are the voltage of the “denominator” input pins D1 and D2 with respect to the reference pin, respectively. Since raising a negative number to non-integral powers is undefined, the signal is considered to be zero when such conditions occur. Hence, in this example, if v_{N2} is less than zero, the output of the particular NLB component is set to zero.

The B input of the NLB_UC3854 component corresponds to the IAC input of the UC3854 PFC controller. Although the IAC input of UC385 is a current-sensing input, the B input of the NLB_UC3854 component, however, is a voltage-sensing input like any other input pins in the entire family of NLB components. Hence, the user needs to be aware of such differences in using the NLB_UC3854 component to model any PFC controller similar to the UC3854 controller.

Slow Simulations Involving NLB components

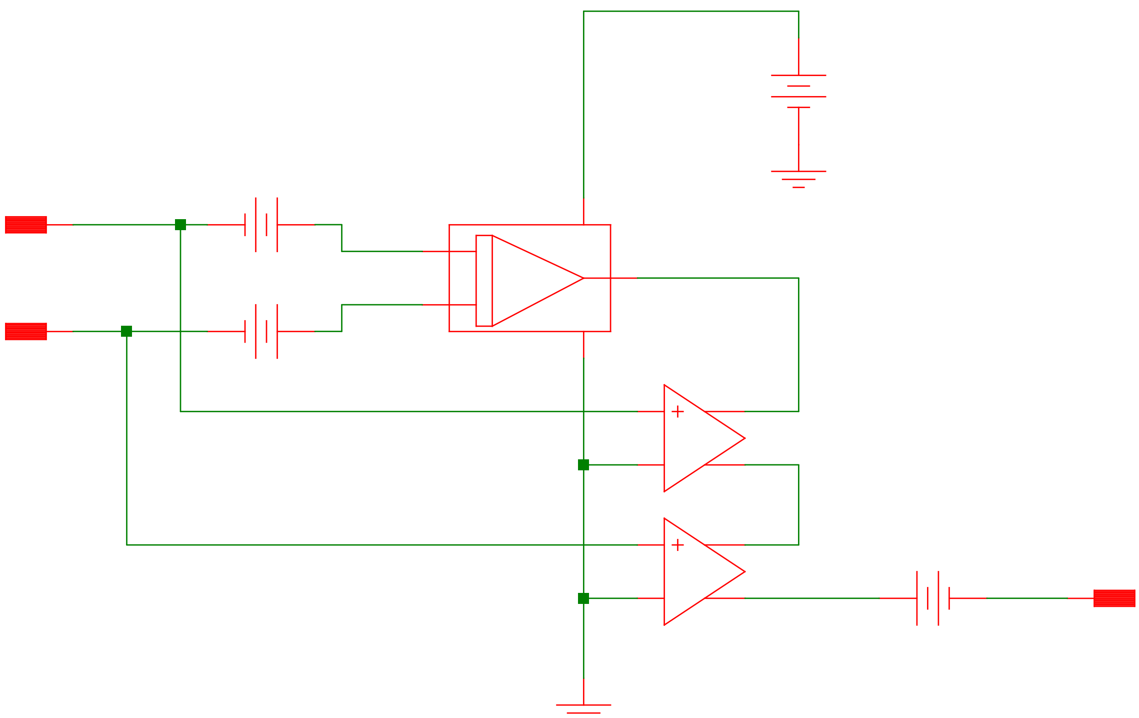
Normally, simulation involving the NLB components would run at simulation speeds typical of a SIMPLIS simulation. The simulation speed time would increase tremendously if one of the "denominator" inputs is either very close to zero, or making either a positive-to-negative transition or a negative-to-positive transition. Proper limiting of the "denominator" inputs may eliminate such slow simulation.

Simple 4-Quadrant Multiplier

In the modeling of 3-phase PFC systems, it is very common that a 4-quadrant multiplication capability is needed. Since the NLB_MULTI and NLB_MULT2_DIV0 components can only produce non-negative outputs, shifting of the inputs and outputs can be carried out to accomplish the 4-quadrant multiplication:

$$\begin{aligned} \text{Output} &= v_A \, v_B \\ &= (v_A + V_{A0})(v_B + V_{B0}) - (v_A V_{B0} + v_B V_{A0} + V_{A0} V_{B0}) \end{aligned}$$

In the above equation, v_A and v_B are the input signals to the multiplier and V_{A0} and V_{B0} are constant offsets. If the V_{A0} and V_{B0} are properly sized so that both $(v_A + V_{A0})$ and $(v_B + V_{B0})$ are always positive, then either the NLB_MULTI or NLB_MULT2_DIV0 component can be used to perform the multiplication of $(v_A + V_{A0})(v_B + V_{B0})$. The terms $v_A \, V_{B0}$ and $v_B \, V_{A0}$ each involve one signal and one constant and they can each be accomplished through a simple voltage-controlled voltage source. Finally, the $V_{A0} \, V_{B0}$ term only involves constants and it can be modeled by a DC voltage source. Hence, the "4-quadrant multiplier" would look like the following:



In this case the source value of the voltage source V_HLIM should be set to a value much higher than the expected maximum of the $(v_A + V_{A0})(v_B + V_{B0})$ product so that it would not interfere with the 4-qudrant multiplication.