Staircase Source Macro

The staircase source produces a waveform that strangely enough looks like a staircase. This type of source waveform is commonly used in video and audio system simulation. It can also be used in many D/A applications such as in linearity testing or testing circuitry such as a digital amplitude modulator. There are a number of different ways to create a staircase waveform. One can add the output of multiple pulse sources together, use the output of a digital to analog converter, or use the PWL capability of the Voltage Source component. Our solution is a simple and very flexible macro circuit for creating a staircase waveform that is displayed in Figure 1.

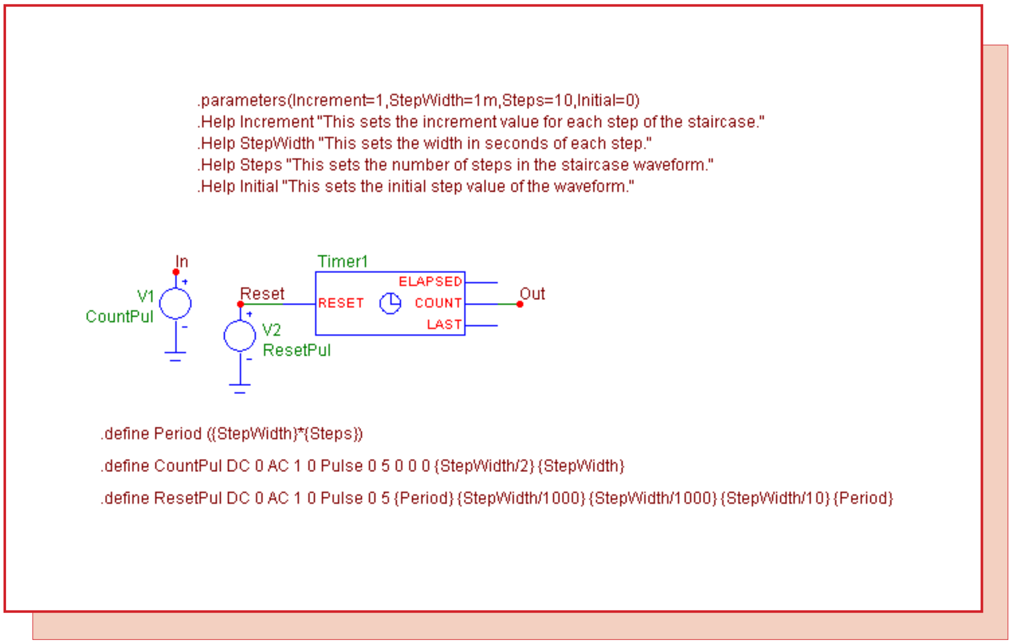

Fig. 1 - Staircase Source Macro Circuit

This macro circuit produces a periodic staircase waveform. The staircase macro has four parameters that are passed to it: Increment, StepWidth, Steps, and Initial. The Increment parameter defines the incremental voltage value for each step of the staircase. The StepWidth parameter defines the width in seconds of each step. The Steps parameter defines the total number of steps that the staircase waveform will consist of. The Initial parameter defines the initial voltage value that the staircase will begin at for each period of the waveform. The period of the waveform is calculated by multiplying the StepWidth and the Steps parameters through a define statement.

The macro circuit consists of two voltage sources and a timer component. The first voltage source, V1, defines the voltage at node In. The VALUE attribute for the source has been defined as CountPul with a corresponding define statement of:

.define CountPul DC 0 AC 1 0 Pulse 0 5 0 0 0 {StepWidth/2} {StepWidth}

This statement produces a pulse with a 50% duty cycle whose period is equivalent to the StepWidth parameter. The source rises immediately to 5 volts at the beginning of each period, and then drops to 0 volts at the midpoint of the period. This source will be used to trigger the counter that resides within the timer component.

The timer is designed to monitor for a specific event in the simulation. The timer counts the total number of events since the start of the simulation or the end of the last reset pulse, the elapsed time since an event occurred, and the last time the event occurred. For the staircase macro, only the counting feature is of interest. The attributes for the timer are as follows:

INPUTEXPR = (V(In) > 2.5) * (t >= {StepWidth})
ELAPSED_SCALE = 1
INCREMENT = {Increment}
INITIAL = {Initial}
MIN = -1e9
MAX = 1e9

The INPUTEXPR attribute is a boolean expression that defines the event to be monitored. In this case, it will record an event when the voltage at node In becomes greater than 2.5 volts and the simulation time equals or exceeds the StepWidth parameter. Since the V1 source at node In creates a 5 volt pulse every StepWidth seconds, the count will be incremented every StepWidth seconds. The simulation time requirement of the INPUTEXPR attribute prevents the timer from recording the very first pulse in the simulation as the V1 source will also create a 5V pulse at time = 0 which should be ignored by the timer.

The ELAPSED_SCALE attribute is used to scale the voltage on the Elapsed pin of the timer. This pin is not used in this macro.

The INCREMENT attribute defines the value that the count will be incremented by each time a valid event is recorded. In this case, it is defined with the parameter Increment that is being passed into the macro.

The INITIAL attribute defines the initial value that the count will be set to when the simulation starts or when a reset pulse is triggered. In this case, it is defined with the parameter Initial that is being passed into the macro.

The MIN and MAX attributes simply define the minimum and maximum values that the counter is capable of counting to.

The current count value of the timer is produced as a voltage on the Count pin of the timer. This count voltage models the staircase waveform.

The second voltage source, V2, is connected to the Reset pin of the timer. The VALUE attribute for the source has been defined as ResetPul with a corresponding define statement of:

.define ResetPul DC 0 AC 1 0 Pulse 0 5 {Period} {StepWidth/1000} {StepWidth/1000} {StepWidth/10} {Period}

The Period variable used here is calculated by multiplying the Steps and StepWidth parameters. This statement creates a five volt pulse every Period seconds after an initial time delay of Period seconds. The pulse width is a tenth of the passed StepWidth parameter which makes sure that the reset doesn't mask the next valid count event. The Reset pin of the timer will reset the count value to its Initial value whenever the voltage on the pin becomes equal to or greater than one volt. The V2 source waveform produces the periodic capability of the staircase waveform.

A sample transient analysis for the staircase source is displayed in Figure 2. The simulation time is 30ms and the staircase macro's parameters have been defined as follows:

Increment = 1
StepWidth = 1m
Steps = 8
Initial = 1

The staircase produces the expected eight steps going from 1 volt on the first step to 8 volts on the

Fig. 2 - Staircase Source Output

final step before being reset. Note that the period of the staircase waveform is 8ms (1m*8). The internal reset node voltage of the macro has also been plotted with the expression:

V(X1.Reset)

where Reset is the node name inside the macro, and X1 is the staircase macro Part designator.