Modeling an Impulse in Simulink

INTRODUCTION

Often a dynamic system is subject to an impulsive load, such as a blow from a hammer. It is important to be able to model such systems to understand what the response will be. This tutorial will discuss three methods for modeling an impulse in Simulink so that it can be used as the forcing function in a dynamic system model. These methods, a square pulse, a half-sine, and a triangular pulse, generate an *approximation* of a basic single impulse. Modeling real-world impulses on a system can be a very difficult task, and may require a combination of the following methods or other more complex methods that are beyond the scope of this tutorial. This tutorial assumes that the reader has a basic working knowledge of Simulink.

SQUARE PULSE

This method is a good first approximation of an impulse, and it simply involves setting the parameters of two Step blocks to simulate an impulse. Start by dragging a Step block and a Scope block into the model. Then, hold CTRL and click and drag the Step block to add a second Step block. Drag a sum block into the model, as well. Connect the blocks as shown in Fig. 1.

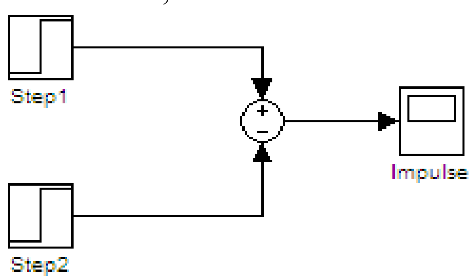

Fig. 1. Step block Impulse model

Now, set the Step block parameters to the values shown in Table 1.

Table 1. Step Block Parameters to create an impulse.

Block	Step Time	Initial Value	Final Value
Step1	0.025	0	1
Step2	0.050	0	-1

Note that the step time either block can be varied to change the duration of the impulse. After running the model, the results should appear as in Fig. 2.

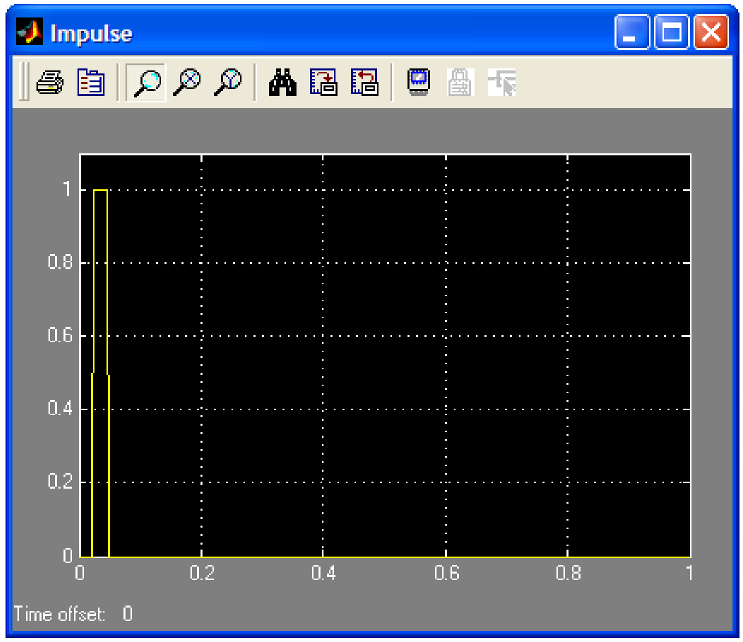

Fig. 2. Step block impulse

A unit-impulse has been created. This input can then be fed into any dynamic system model to simulate an impulsive load.

HALF-SINE PULSE

This method is a little more sophisticated, and will give a more realistic approximation of a typical impulse. To construct this model, drag a Sine block, Product block, and Step block into the model. Connect the blocks as shown in Fig. 3.

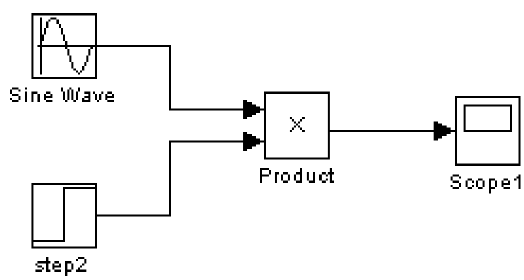

Fig. 3. Half-sine impulse model.

Now use the values inTable 2 to set the block parameters. The values to be determined (T.B.D) are the step time and the frequency of the sine wave.

Table 2. Block Parameters for Half-sine Impulse

Block	Property	Value
Sine Wave	Amplitude	1
	Bias	0
	Frequency (rad/sec)	T.B.D
	Phase (rad)	0
	Sample Time	0
Step2	Step Time	T.B.D
	Initial Value	1
	Final Value	0
	Sample Time	0

The step time is simply the required duration of the impulse, in this example a value of 0.1 was used. The frequency of the sine wave can be calculated as

$$frequency\ of\ \ sine\ wave = \frac{\pi}{(required\ impulse\ duration)}\ . \tag{1}$$

Now open the Scope block to view the results. The results should be similar to Fig. 4.

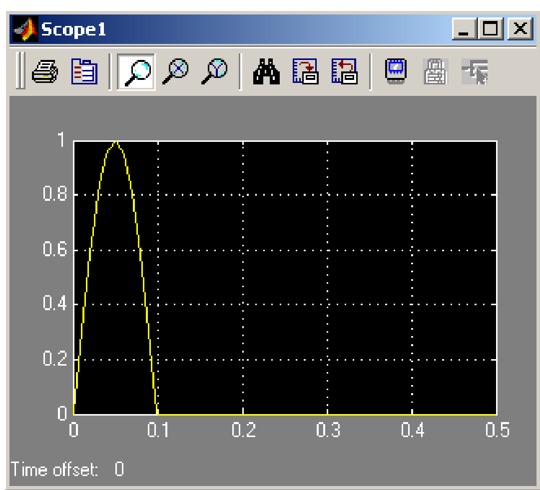

Fig. 4. Half-sine unit impulse.

TRIANGULAR PULSE

A final pulse shape that may be of use is the triangular pulse. This pulse shape is consistent with a hard-tipped impactor and occurs frequently in practice. Begin by going to the ***Simulink Library Browser*** → ***Sources***, and bring two ***Ramp*** blocks into the model. Now go back to the browser and select ***Nonlinear***, and bring two ***Saturation*** blocks into the model. Using a ***Sum*** block and ***Scope***, assemble the model as shown in Fig. 5.

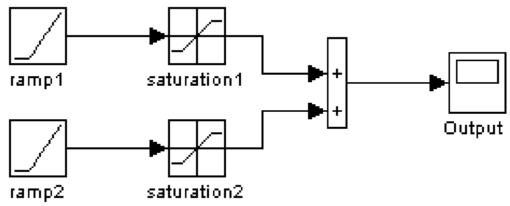

Fig. 5. Triangular pulse model.

Next, to create a unit triangular impulse with a duration of 0.1 seconds, set the parameters for the first ramp (ramp1) to the values shown in Fig. 6.

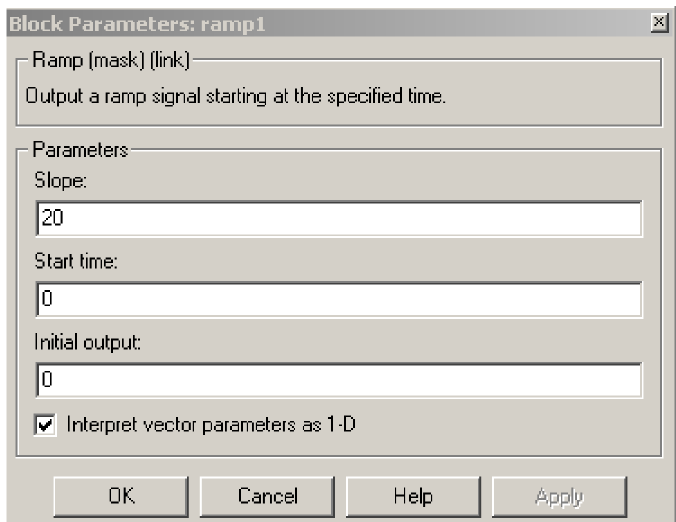

Fig. 6. Block parameters for ramp1.

For the ramp2 block, the slope is negative (-20 in this case) and the start time is equal to half of the total pulse duration desired, or 0.05 seconds for this example. Next, set the parameters of both Saturation blocks to the values shown in Fig. 7.

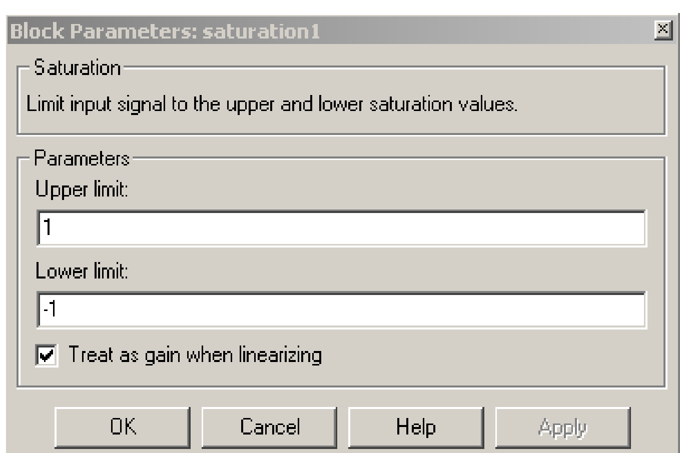

Fig. 7. Block parameters for saturation blocks.

The saturation block essentially limits the ramp signal at the set value, which for this example is unity, but could be any desired value. When the model is run, a triangular pulse should result as shown in Fig. 8.

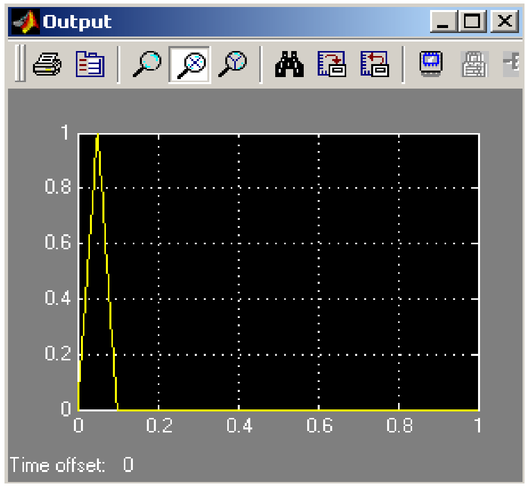

Fig. 8. Triangular unit impulse.

These methods for generating an impulse should allow for a good approximation of real-world conditions. Any of these methods can be combined to model a more specialized case. If very accurate results are required, it is best to take an actual measurement of the desired impulse using a force gage and import the data into Simulink.