

A New Smooth Step Function For ADAMS

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Introduction

The STEP function in ADAMS provides a means of transitioning from a value constant value to another value of a function over a specified interval of an independent variable. The function value transition is by means of a cubic polynomial fit between the two user specified transition points. As shown in figure 1 the transition point are specified as x_1 and x_2 value of an independent variable x . Between these two points the function value transitions from a value of h_1 to h_2 . While this results in a function that is continuous, the derivative of such a function while continuos have sharp corners at the transition points. This rapid change can cause difficulties in numerical integration of dynamic models. The present paper proposes an alternative step function called NEW_STEP that has a smooth function value during the transition and also has smooth changes in the first derivatives of the function at the transition points of the function.

NEW_STEP Function

The ADAMS step function gives a function

$$f(x) = \begin{cases} h_1 & x < x_1 \\ f(x, x_1, h_1, x_2, h_2) & x_2 \geq x \geq x_1 \\ h_2 & x > x_2 \end{cases}$$

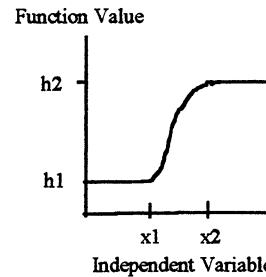


Figure 1. ADAMS Step Function

NEW_STEP function in the range x_1 to x_2 of the independent variable is given as

$$f(x) = h_1 + [\Delta h / \Delta x] * (x - x_1) - [\Delta h / 2\pi] * \sin\{(2\pi / \Delta x) * (x - x_1)\} \quad (1)$$

where

$$\Delta h = h_2 - h_1$$

$$\Delta x = x_2 - x_1$$

From (1) it can be seen that

$$f(x_1) = h_1 \quad (2)$$

and $f(x_2) = h_2$

First derivative of $f(x)$ with respect to the independent variable x is given as

$$f'(x) = [\Delta h / \Delta x] - [\Delta h / \Delta x] \cos\{(2\pi / \Delta x) * (x - x_1)\} \quad (3)$$

From (3) we obtain

$$f'(x_1) = 0 \quad (4)$$

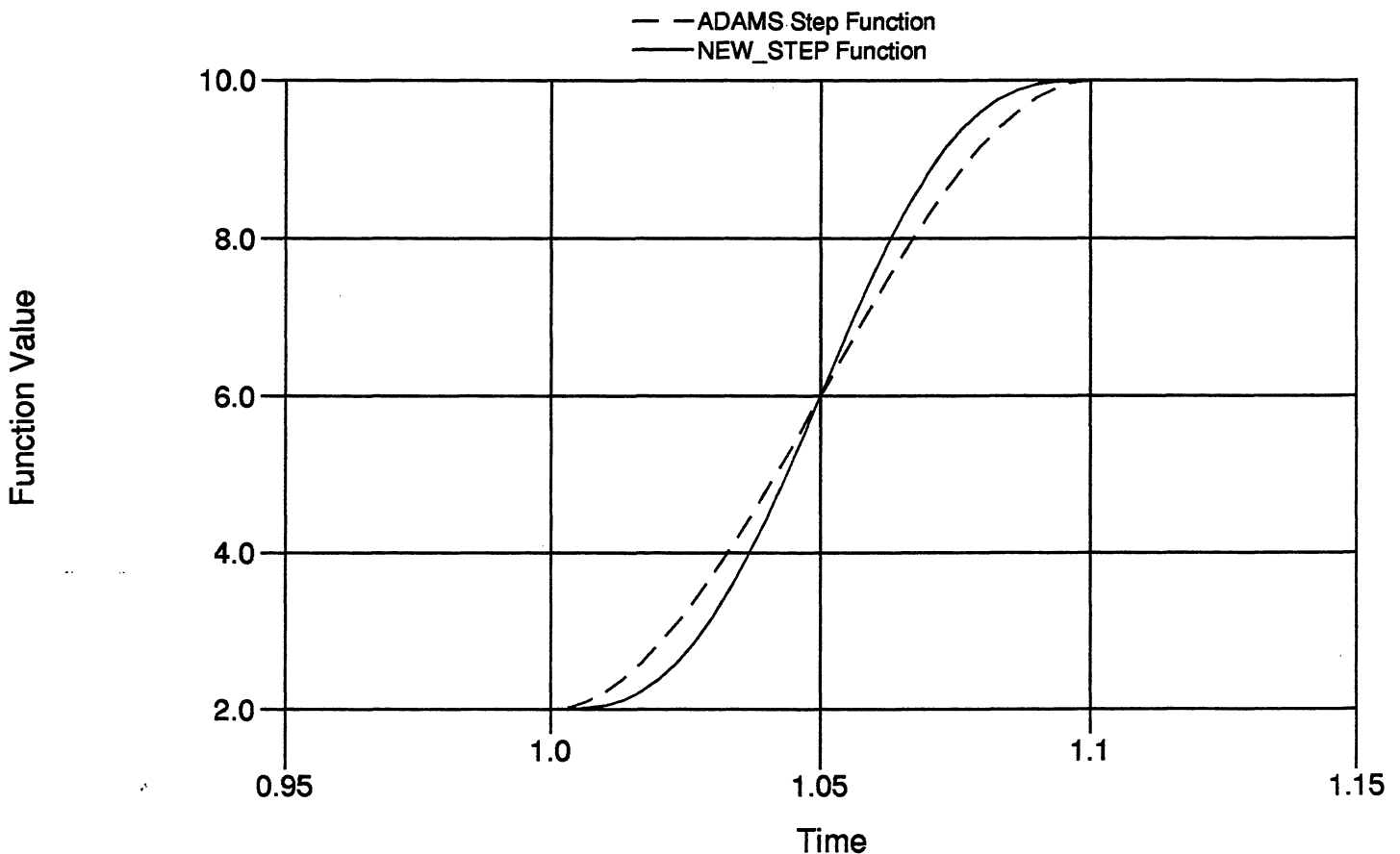
$$f'(x_2) = 0$$

As can be seen from (2) NEW_STEP satisfies the desired transitional properties of the Step function. In addition (4) shows that NEW_STEP has zero slope at the end points of the transition. This results in a smooth transition between the function values of h_1 to h_2 .

Simulation Results

A model with 1 moving part and an SFORCE with a STEP function was simulated. In the first model ADAMS step function was used to transition the SFORCE from 2 newtons at 1.0 seconds to 10 newtons at 1.1 seconds. In the second model the same SFORCE was transitioned using the NEW_STEP function. Figure 2 shows a comparison of the SFORCE generated by model 1 and model 2. Figure 3 shows a comparison of the derivative of the force. As can be seen in figure 3 NEW_STEP gives much smoother derivatives as compared to ADAMS Step at entry into the transition at 1.0 seconds and also on exit from the transition at 1.1 seconds. This smoother transition characteristic should reflect in smoother integrator behavior.

Figure 2 Comparison of STEP functions



Summary

This paper presented an alternative step function formulation of the ADAMS step function. The proposed step has smoother transition characteristics at the in and out points of the step transition region. The NEW_STEP formulation may be introduced in future releases of ADAMS.

While not presented in this paper, the NEW_STEP function is extensible to accommodate non-zero slopes at the in and out points of the step function. Contact the author for further information on this extension.

Acknowledgment

The author would like to acknowledge similar work done by Dr-Ing. Zamow at Porsche AG in Germany. The Present work was done independent of the work at Porsche and came to light to the author only after the present work had been completed.

FORTRAN source code implementing the NEW_STEP function is available on request from the author.

Figure 3 Slope of Step Function

