February 1971

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Brief 71-10003

NASA TECH BRIEF *Marshall Space Flight Center*

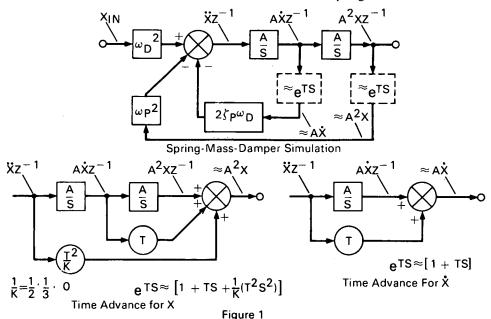


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Digital Simulation Error Curves for a Spring-Mass-Damper System

The problem:

Reduce the excessive number of samples per cycle and the unnecessary iterations which increase cost and computation time on digital simulations of continuous data systems. $A = \omega \begin{pmatrix} 1 \\ S \end{pmatrix}$ is the normalized integration gain. ω_D is the effective angular resonance frequency. ω_P is the programmed angular resonance frequency. ζ_P is the programmed damping ratio. T is the sampling interval in seconds.



The solution:

Plot the digital simulation errors for a springmass-damper system. Using these error curves, select the type of integration, the feedback update method, and the number of samples per cycle at resonance.

How it's done:

Block diagrams of a spring-mass-damper simulation and the preferred time advance update method are shown in Figure 1, where: Z^{-1} is a transfer function for T seconds time delay. e^{TS} is a transfer function for T seconds time advance. $\frac{1}{k}$ is a constant for time advance update.

I is the number of iterations for iteration update.

X, \hat{X} , and \hat{X} represent the mass displacement, velocity, and acceleration, respectively.

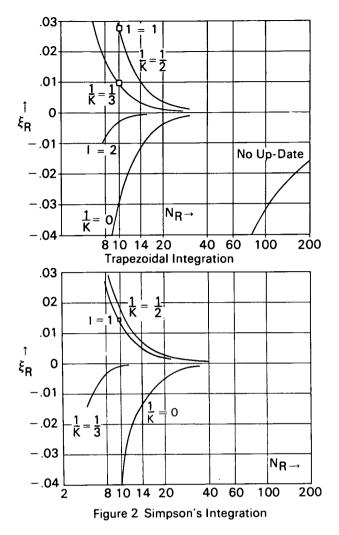
S is the Laplace operator.

 N_R is the number of samples per cycle at resonance.

The effective damping ratio is:

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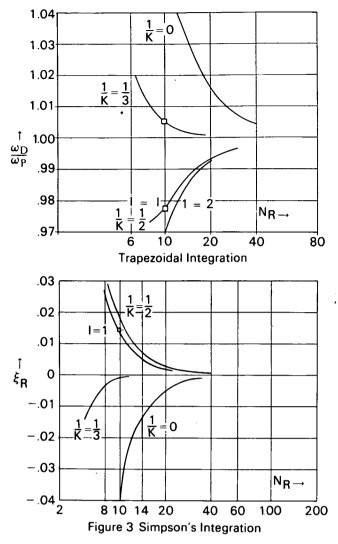
 $[\]zeta_{\rm D} \approx \zeta_{\rm P} + \xi_{\rm R}$ (continued overleaf)



where ξ_R is the damping bias error. This error is plotted (Figure 2) for trapezoidal integration and Simpson's 1/3 formula, where N_R is the number of samples per cycle at resonance. Curves are shown for the iteration update method where I = 1, and for the time advance update method where 1/K = 0, 1/3, and 1/2.

The normalized resonance frequency, ω_D / ω_P , shown in Figure 3, is for trapezoidal integration and Simpson's 1/3 formula.

For the curves for trapezoidal integration, the time advance update method with 1/K = 1/3 has smaller errors at 20 samples per cycle than the one-iteration update method at 30 samples per cycle. Thus, for the same accuracy, the time advance update method will solve the simulated problem in half the time of the one-iteration update method. This is based on an added time per iteration of T/4, i.e., one-quarter of the computation time without iteration.



Note:

Requests for further information may be directed to:

Technology Utilization Officer Marshall Space Flight Center Code A&TS-TU Huntsville, Alabama 35812 Reference: B71-10003

Patent status:

No patent action is contemplated by NASA.

Source: Lewis Alfred Knox of International Business Machines Corp. under contract to Marshall Space Flight Center (MFS-20770)