Analytical Energy Expressions for a Generally Damped Linear System

R. David Hampton
Mechanical Engineering Division
Civil and Mechanical Engineering Department
U. S. Military Academy
West Point, NY

Robin S. Langley
Mechanics, Materials, and Design Division
Department of Engineering
University of Cambridge
Cambridge, UK

Joseph Walchko
Mechanical Engineering Division
Civil and Mechanical Engineering Department
U. S. Military Academy
West Point, NY

Ami Frydman
Ordnance Materials Branch
Weapons & Materials Research Directorate
U. S. Army Research Laboratory
Adelphi, MD

ABSTRACT:

Detailed shock response of military hardware entails a wide range of frequencies, and requires transient analysis. Deterministic methods, such as finite element analysis (FEA), though transient-capable, are slow and accurate only for lower frequencies. On the other hand, statistical methods, such as statistical energy analysis (SEA), are fast but accurate only for higher frequencies. As for model-development and model-based shock-analysis, SEA is significantly less time-consuming than FEA, and offers much more flexibility for model changes. And hybrid methods, such as FEA-plus-SEA, can now address the full frequency range. Further, mean and variance equations have become recently available for both SEA and FEA-plus-SEA hybrid methods. However, for transient analysis—needed for shock response—available statistical treatments still lack adequate mathematical support. This paper seeks to help address the need by offering exact (deterministic) analytical expressions for the potential and kinetic energies of a state-space system subjected to idealized (Dirac-delta) shock loading, as a function of time.

KEY WORDS: shock, vibration, plate, energy

CONTACT: Prof. R. David Hampton, P.E., Department of Civil and Mechanical Engineering, USMA, West Point, NY 10996, USA
Tel: (845) 938-8398; email: roy.hampton@usma.edu

Prof. Robin S. Langley, Head of Mechanics, Materials, and Design Division, Department of Engineering, Trumpington Street, University of Cambridge, Cambridge, England CB2 1PZ, UK
Tel: 44-(0)1223-766385; email: rsl21@hermes.cam.ac.uk

MAJ Joseph Walchko, Department of Civil and Mechanical Engineering, USMA, West Point, NY 10996, USA
Tel: (845) 938-7189; email: joseph.walchko@usma.edu

Ami Frydman, Ph.D., Ordnance Materials Branch, Weapons & Materials Research Directorate, ARL, Adelphi, MD 21005, USA
Tel: (301) 394-2806; email: afrydman@arl.army.mil