Passive Gust Load Alleviation In a Truss-Braced Wing Using an Inerter-Based Device

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This paper presents a novel method for gust loads alleviation in a truss-braced wing in which an inerter-based device located in the truss structure is used to reduce peak-loads during a discrete “1-cosine” gust. Recent studies have shown that gust loads and flutter are critical to the wing sizing and the overall performance of the truss-braced wing concept and it is understood that without additional efforts to mitigate against these effects the benefits of the truss-braced wing concept may be significantly reduced. It is demonstrated that the use of a tunable device known as a tuned inerter damper allows specific vibration modes to be targeted during the gust response, resulting in a reduction of 25% in root bending moment and 5% in root torque when tuned to the second global wing bending mode. Furthermore, it is noted that the force coefficients of the tuned inerter damper are small in comparison with the pure damper device and could be feasible within the scope of an aerospace application.

I. Nomenclature

\[A_0, A_1, A_2 = \text{transfer function coefficients for the dependent degree of freedom}\]
\[B_0, B_1, B_2 = \text{transfer function coefficients for the independent degree of freedom}\]
\[b = \text{inertance}\]
\[c = \text{viscous damping coefficient}\]
\[e = \text{MSC.Nastran EPOINT}\]
\[f_1, f_2 = \text{force at terminal 1 and terminal 2 of the vibration suppression device}\]
\[F_g = \text{flight profile alleviation factor}\]
\[H = \text{gust gradient}\]
\[k = \text{spring stiffness}\]
\[p = \text{Laplace variable}\]
\[s = \text{MSC.Nastran SPOINT}\]
\[u_d = \text{transfer function dependent degree of freedom}\]
\[U_{ds} = \text{gust design velocity}\]
\[u_i = \text{transfer function independent degree of freedom}\]
\[U_{ref} = \text{reference gust velocity}\]
\[V = \text{aircraft forward speed}\]
\[w_g = \text{vertical gust velocity}\]
\[x_1, x_2 = \text{displacement at terminal 1 and terminal 2 of the vibration suppression device}\]
\[\dot{x}_1, \dot{x}_2 = \text{velocity at terminal 1 and terminal 2 of the vibration suppression device}\]
\[\ddot{x}_1, \ddot{x}_2 = \text{acceleration at terminal 1 and terminal 2 of the vibration suppression device}\]
\[Y = \text{generic transfer function}\]
\[\phi = \text{modal coordinate}\]
\[\omega = \text{tuning frequency of the vibration suppression device}\]

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