Abstract

Demonstration of flutter stability over the design envelope and identification of safe flight envelope is a prerequisite for operational clearance of any new aircraft design. An important step involved in flight flutter testing is the proper use of flutter prediction techniques to accurately predict flutter. This study focuses on flutter estimation techniques given flight test data. We review various flutter prediction techniques by simulating them on a three-degree-of-freedom aeroelastic system. We show that flutter margin and an auto-regressive model based approach are robust and reasonably accurate in predicting flutter onset. Using these two techniques, flutter margins are computed at flight test points obtained from flight test data of flexible aircraft. Throughout, we have predicted flutter dynamic pressure at constant Mach number. One of the contributions of this work is in predicting flutter dynamic pressure at transonic Mach numbers. A critical issue in flutter prediction is the lack of information on the flutter instability mode and thereby the number of modes to include in a model. In a novel application of tools from statistical signal processing, we determine the optimum model order to construct an auto-regressive model using the flight flutter test time response data. From this auto-regressive model the frequency and damping values are estimated which in turn is used to estimate aeroelastic stability parameters. High resolution property of auto-regressive technique even with short data records is demonstrated in this thesis. This will provide a quick evaluation of spectral estimate and stability parameter using the same auto-regressive model, facilitating a quick envelope expansion. Aeroelastic stability during wake penetration is an essential part of operational clearance of new aircraft. In this thesis, and perhaps one of the first such study, wake flight test response data is used to assess the stability of the aircraft during wake penetration by modeling the wake response data in an auto-regressive framework. We have compared analytical predictions of incremental load factor based on simulations with flight tests on wake interactions. Estimates for safe wake encounter distance that do not exceed structural limit load factors have been determined.