Ali Talib Abd Al Zahra. Control of Periodic Motion in Aircraft Lateral-Directional Dynamics via Lyapunov Exponent Criterion. University of Technology. Machine and Equipment Engineering Department. M.Sc. Supervised By: Assist. Prof. Dr. Emad N. Abdulwahab and Dr. Qasim A. Atiyah. 2012. 67p.

Abstract

A violent coupled longitudinal-lateral motion encounters the high performance aircraft at moderate to high angles of attack. This coupling is characterized as a periodic motion or limit cycle oscillation (L.C.O) and called a wing rock.

A candidate mechanism for wing rock limit cycle is the inertia coupling between an unstable lateral-directional (Dutch roll) mode with a stable longitudinal (short period) mode. The coupling mechanism is provided by the nonlinear interaction motion related term in the complete set of motion equations. To demonstrate the state variables of aircraft in limit cycle oscillation (L.C.O), the complete nonlinear state equations of aircraft are solved. A numerical model constructed for a high performance aircraft F-15 is solved to illustrate the results.

A novel analysis including the bifurcation and amplitude of limit cycle oscillation as a function of angle of attack was obtained. This analysis is important to estimate the onset of L.C.O.

Wing rock preventing is an important object for an aircraft that needs to fly and maneuver at high angles of attack, and needs to be avoided at all costs. In present work, a robustness control system was designed for suppressing wing rock motion, in which the system would not give any error in a desired time, therefore, the Fuzzy logical controller (FLC) was used as a reliable method to satisfy the present work goal. The numerical

results show that the amplitude response of roll angle and other state variables reach their steady state condition without any error in time about (12 sec). These results exhibit good agreements with published work.
FLC method gives gain about 20% (12 sec.) in steady state variables time in comparison with other published methods (16 sec.).

A methodology for the existence of L.C.O based on Lyapunov exponent criterion was presented. In present work, a new behavior is obtained by tracking the Lyapunov values during all period to verify the control of state variables.

It has been found that the present work can be considered as an efficient numerical tool used for many dynamic systems, such as robotics, traking control ship, engine control system, etc.

Keywords: Wing rock suppression; nonlinear dynamics system; limit cycle oscillation; control of periodic motion; Lyapunov exponent criterion; Fuzzy logical controller.