Exercise no. 2

MULTI-STEP INPUT DESIGN

The following equation describes aircraft motion:

$$\begin{bmatrix} \dot{u} \\ \dot{\alpha} \\ \dot{q} \\ \dot{\theta} \end{bmatrix} = \begin{bmatrix} X_u & X_\alpha & X_q & -gcos(\Theta_0) \\ Z_u & Z_\alpha & Z_q + 1 & gsin(\Theta_0) \\ M_u & M_\alpha & M_q & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} u \\ \alpha \\ q \\ \theta \end{bmatrix} + \begin{bmatrix} X_{\delta_E} \\ Z_{\delta_E} \\ M_{\delta_E} \\ 0 \end{bmatrix} \delta_E \tag{2.1}$$

where: u - longitudinal velocity, m/s; α - angle of attack, rad; q - pitch rate, rad/s; θ - pitch angle, rad; δ_E - elevator deflection, rad. A-priori values for stability and control derivatives are given as:

$X_u = -0.04,\ 1/s$;
$X_\alpha = 5.45,\ m/s^2$;
$X_q = -0.40,\ m/s$;
$X_{\delta_E} = -0.60,\ m/s^2/rad$;
$Z_u = -0.01,\ 1/s$;
$Z_\alpha = -1.30,\ m/s^2$;
$Z_q = -0.02,\ m/s$;
$Z_{\delta_E} = -0.09,\ m/s^2/rad$;
$M_u = 0.01,\ m/s$;
$M_\alpha = -6.75,\ m^2/s^2$;
$M_q = -3.00,\ m^2/s$;
$M_{\delta_E} = 10.60,\ m^2/s^2/rad$.

Pitch angle in the trim point is $\Theta_0 = 0\ rad$, whilst gravitational acceleration $g = 9.80665 m/s^2$

Based on the given model:

- find identifiability ranges of stability and control derivatives,
- find switching times for short-period mode Δt_{SP} and phugoid mode Δt_{PH},
- present time histories of the aircraft response for the designed excitations.

References

[1] Jategaonkar R.V., Flight Vehicle System Identification: A time domain methodology, 2 ed., AIAA, Reston, VA, 2015