

Homework–7 (Due date: Thu, Nov 16, 2006)

Textbook Readings: Sections 7–1, 7–2, 7–3 and 7–4 Examples A–7–5 and A–7–6

- 1.** B–7–7 in the textbook.
- 2.** B–7–8 in the textbook.
- 3.** B–7–10 in the textbook.

Design Project Assignment–7 (Due date: Thu, Nov 16, 2006)

1. At this stage of the project, we have stabilized the aircraft and designed a P-controller to achieve tracking of bank angle reference commands. Now that the control system can bank the aircraft to any desired angle, our objective is to close a loop using the heading angle ψ as the measurement to achieve tracking of heading reference commands. Once we do this, we can specify the heading which we want to follow and the control system will bank the aircraft to effect a turn and roll out once the desired heading is reached.

- (i) Design a compensator $G_{c\psi}(s)$ using the feedback structure shown below to achieve asymptotic tracking of heading step commands with a 25 second rise time. You are free to use any compensator structure (P, PI, PID PD, etc) you want. Note from Assignment 1 that $g = 9.81m/s^2$ and $U_0 = 67m/s$.

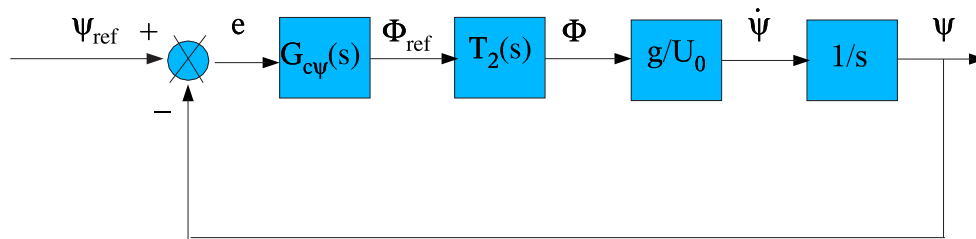


Figure 1: Block Diagram for Heading Angle Tracking

$T_2(s)$ is the closed-loop transfer function shown in Figure 2 of Assignment 6.

2. (SIMULINK)

- (i) Simulate the closed-loop heading control system using the controller that you designed in part 1 for 50 seconds. Command a heading change of 30 degrees by setting the value of the step input to 30 degrees and the step time to 0 seconds in the step-input block of your SIMULINK block-diagram. Make sure that the "To Workspace" block have the same variable names as in Assignment 6.
- (ii) Copy the animation program called **animation_roll_yaw.m** from ASSIGNMENTS folder in the ftp site. After simulating your closed-loop heading control system, type `>>animation_roll_yaw` on the MATLAB screen to run the animation file. You will verify that a heading change of approximately 30 degrees takes place. Please note that this M-file assumes that your simulink model loads to the workspace the simulation time as **tt** or **tout** in seconds, yaw angle as **psi** in degrees and bank angle as **phi** in degrees.

3. (Guidance). Now that we are available to make the aircraft make prescribed heading changes, our task is to develop a system by which the heading control system is given the

appropriate heading commands so as to align the aircraft with the runway centerline. We start by considering the geometry of the problem as depicted in Fig. 2. For simplicity, we assume that the runway centerline is aligned with the North-South axis and that $\psi(t)$ and the heading error $\Gamma(t)$ are small. From the figure,

$$\sin\Gamma(t) = \frac{d(t)}{R(t)}, \quad (1)$$

or, since $\Gamma(t)$ is small,

$$\Gamma(t) \approx \frac{d(t)}{R(t)}. \quad (2)$$

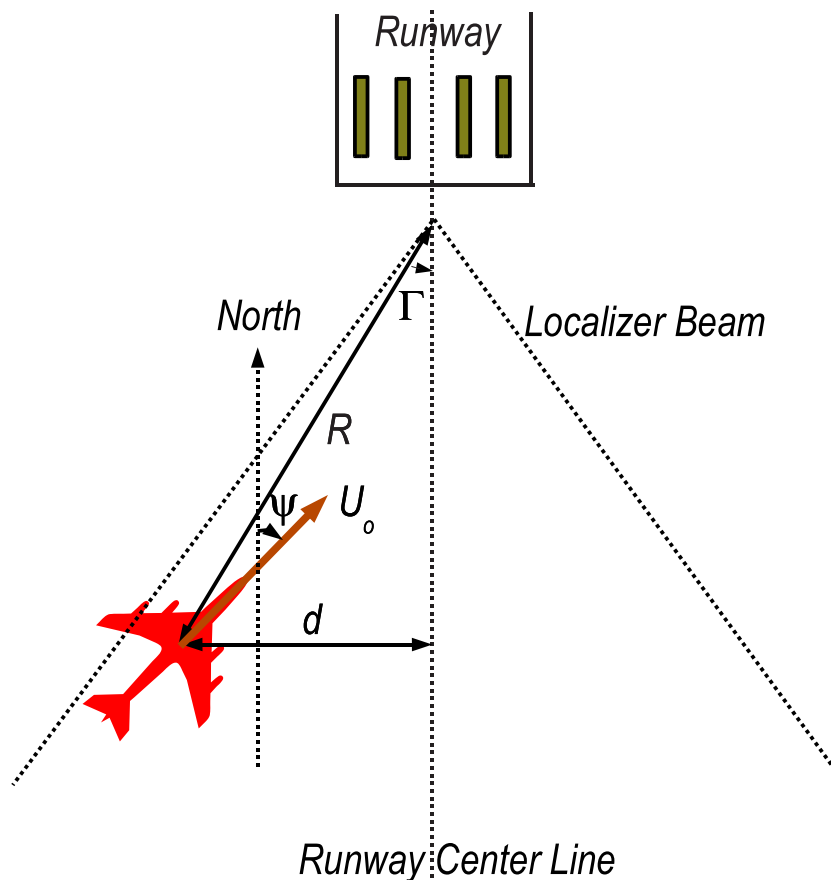


Figure 2: Geometry of Automatic Landing System (Heading Control)

Next,

$$\dot{d}(t) = U_0 \sin \psi(t) \approx U_0 \psi(t), \quad (3)$$

and thus,

$$\Gamma(t)_{deg} = \left(\frac{\int_0^t U_0 \psi(t) dt}{R(t)} \right) \left(\frac{180}{\pi} \right). \quad (4)$$

Our final control objective will be to drive the heading error $\Gamma(t)$ as close to zero as possible by the time the aircraft is around 5000 meters from the runway.

Include a set of SIMULINK blocks to simulate equation (4) in the SIMULINK figure that you have been developing over the semester for the project. You will use the heading angle $\psi(t)$ (converted to radians through a gain block) and the range $R(t)$ from the range subsystem which you built in Assignments 1 and 2. You will need to use an integrator block, a "MATLAB Function Block" from the **Nonlinear** Block library to calculate $\frac{1}{R(t)}$, a gain block and a product block. Set the initial value of ψ to 5 degrees in the integrator block that integrates $\dot{\psi}$ to give ψ and set the initial value of d to 1000 meters in the integrator block that integrates \dot{d} to give d . Simulate the system for 50 seconds and plot $\Gamma(t)$ versus time.