

Lecture S10 Muddiest Points

General Comments

Today, we mostly talked about an example using Laplace transforms. I didn't get the algebra quite right — my apologies. I will post a set of notes that does the algebra correctly.

Responses to Muddiest-Part-of-the-Lecture Cards

(19 cards)

1. **What's the meaning of "gain"?** (2 students) In the airplane control example, the control signal $u(t)$ was formed by multiplying the error signal $e(t)$ by a number, k . This number is called a "gain." More generally, if the control block had been a transfer function $K(s)$ rather than a static number, we would still call the magnitude of the transfer function $K(j\omega)$ at each frequency ω the "gain" at that frequency.
2. **Does the "vomit comet" (the NASA KC-135) use the phugoid mode to fly its parabolic flight path?** (1) Not really. In a phugoid, the coefficient of lift C_L is constant. In the KC-135, the zero-g parabola is flown at a lift coefficient of zero, and the high-g parabola (the pull-up) is flown at constant g-level, not constant lift coefficient.
3. **In the DC-10 case where the engine broke off, might the computer save the plane by diagnosing the problem, and shutting down the engine before it comes off?** (1) Only if there were a way to measure the impending structural failure. But the aircraft was designed to never have a structural failure, so there is no sensor built in to measure the possible failure.

4. **Why is**

$$G(s) = \frac{H(s)}{T(s)}$$

(2 students) Because δT (with LT $T(s)$) is the input to the system, and we the output signal we care about is δh (with LT $H(s)$). The ratio of these is the transfer function, $G(s)$.

5. **Confused about where the damping term (in the phugoid) came from.** (1) At the bottom of the phugoid, where the velocity is the greatest, the drag increases. At the top of the phugoid, the velocity is at its lowest, and the drag decreases. This reduces the amplitude of the phugoid a little bit on each cycle.
6. **Uh oh, I don't remember partial fractions.** (1) Please take a look at the notes, and we will probably do some in recitation next week.
7. **Lost you on derivation of ω_n . What is ζ ?** (2) When you factor a polynomial in the denominator of a transfer function, it factors into first order polynomials like $s + p$, corresponding to real roots, and second order terms like $s^2 + 2\zeta\omega_n s + \omega_n^2$, corresponding to complex roots. ω_n is the "natural frequency," and ζ is the "damping ratio." The natural frequency is basically the frequency of oscillation, and the damping ratio is a non-dimensional measure of the amount of damping in the oscillation.

8. *At which points in the phugoid oscillation would you add or decrease thrust in order to stabilize the motion? (1)* You would add thrust at the top, and reduce thrust at the bottom.
9. *Is there enough computing power on board an aircraft to have a dynamic gain? (1)* Yes, by a long shot. It doesn't take much computing power, and almost all control laws are dynamic.
10. *How did you do the linearization? (1)* Please look at the phugoid notes when I post them.
11. *What we supposed to get from the lecture? (1)* That we can use Laplace transforms to analyze systems other than just circuits. Even nonlinear aircraft dynamics can be understood, if they they are first linearized.
12. *Can you re-explain the aircraft block diagram? (1)* The "airplane" is the block G . Its input is $\delta T(t)$ (the change in thrust). The output is the change in altitude, $\delta h(t)$. K is the control law, which takes as its input the error signal $e(t)$, and output $u(t)$.
13. *No mud. (4)* Good. Some comments: *Should I write home and tell my family to never fly on a DC-10?* No. By now, they have found many of the problems with the DC-10, and it's probably as safe as most other models. *The airplane miracle cases are awesome.* Good. They are really interesting.