

Homework Assignment #2

ECE 597UU/697UU, Fall 2009

(Posted on the course website on Thu, 24 Sep; due in class on Tue, 29 Sep)

Problem 1 (16 pts.): *Measurement error due to delay*

Consider a CT measurement system that can be modeled as an ideal delay system with delay $T_d = 1 \mu\text{s}$. For each subproblem, you get up to 2 pts. for the approach and up to 2 pts. for the correct result. (You get no credit for the correct result if you don't explain where it comes from.)

(a, 4 pts.) Find the impulse response $h(t)$.

(b, 4 pts.) Find the frequency response $H(j\Omega)$.

(c, 4 pts.) Suppose the input signal is a real-valued sinusoid with period $T = 10 \mu\text{s}$ and amplitude $A = 1 \text{ V}$. Find the r.m.s. value σ_e of the measurement error e ,

(d, 4 pts.) As (c), but for the case that the delay is not deterministic but a random variable with a Gaussian p.d.f. and a standard deviation of $1 \mu\text{s}$.

Problem 2 (10 pts.) *Thermal noise and digitization noise*

Consider a thermocouple thermometer with a sensitivity of $40 \mu\text{V K}^{-1}$. Suppose that the error in the voltage measurement is the sum of some thermal noise $n(t)$ and of the digitization error $q(t)$, where $\sigma_n = 1 \mu\text{V}$ is the thermal noise standard deviation and s is the digitization step. Suppose further that the digitization error and the thermal noise are statistically independent.

(a, 2 pts.) What is the precision of the temperature measurements if there is no quantization?

(b, 4 pts.) What is the precision of the temperature measurements if $s = 1 \mu\text{V}$.

(c, 4 pts.) What is the maximum allowed s if the total r.m.s. temperature error must not exceed 110% of the r.m.s. error caused by thermal noise?

Problem 3 (4 pts.): *Effect of Earth-Sun distance on solar constant and Earth's equilibrium temperature*

(a, 2 pts.) If the Earth were by $p\%$ (where p is smaller than, say, 10) closer to the Sun, by how many percent would the solar constant increase? Give an analytical justification.

(b, 2 pts.) If the Earth were by $p\%$ (where p is smaller than, say, 10) closer to the Sun, by how many percent would the Earth's equilibrium temperature increase? Give an analytical justification.

Problem 4 (10 pts.): *The "lunar constant"*

Let L_0 be the "lunar constant", that is, the total radiative power that arrives at the top of the Earth's atmosphere from the full moon. Make the following assumptions: (1) The albedo of the Moon is 0.12; (2) the distance between Sun and Moon is practically identical to the distance between Sun and Earth; (3) the angular diameter of the Moon (as seen from the Earth) is practically identical to

the angular diameter of the Sun (as seen from the Earth). — Estimate L_0 and compare the result with S_0 . (Note: The Moon does not rotate about itself.)