Dynamic Performance Characteristics

Meteorology 432

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Changing modes

- When the input to a sensor is changing rapidly, we observe performance characteristics that are due to the changing input and not related to static performance.

- Redefine “linear”
  - Static: constant static sensitivity.
  - Dynamic: applicability of the superposition property.

- A sensor can be nonlinear in the static sense, but could be linear in the dynamic sense (modeled by a linear differential equation).

Dynamic Performance Characteristics

- Define the way instruments react to measured quantity fluctuations.

- Examples

First Order Systems

- Differential equations describe the behavior of physical systems.

- First property: For a linear system, the response to a sum of inputs is simply the sum of the responses to those inputs!
  - "The response to a sum is the sum of the responses".
  - Superposition principle.

- Second property: For a linear system, the response to an input multiplied by a constant is the response to the input applied separately multiplied by the same constant.
  - "If the input is multiplied by a constant, the output is multiplied by the same constant."

Definitions

- Static State: systems variables do not depend on time.
  - All time derivatives in the differential equation are equal to zero.

- Dynamic State: equations contain time derivatives.

- When forces are applied at discrete points and are transmitted by discrete components within the system, the system can be defined by lumped parameters.

- Dynamic performance analysis is concerned with modeling the performance of dynamic, lumped parameter systems, with ordinary differential equations, where time is the independent variable.
  - If it is necessary to describe the variation across space, the system must be described with distributed parameters (continuum), and is modeled by partial differential equations.

- Order of the system = number of dynamic performance parameters.

Ramp Input - Example

- Suppose you have subjected your thermometer to a steadily rising temperature after it was kept at a constant temperature for a while (equilibrium with environment).

- The reading of the thermometer will always lag with respect to the real temperature – it takes time to settle.

- To minimize this effect, you would choose a thermometer with a very small time constant.

Sinusoidal Input – Example

- Suppose our thermometer was kept at equilibrium with the environment, and then was subjected to a sinusoidal input (change in temperature)

- If the temperature variation is slow (low frequency), the sensor output will simply follow the ambient input.

- If the temperature variation is very fast, the sensor output will be very small (it will stay at the reading prior to the beginning of the input)
  - Simply unable to follow the fast variations!!

- What is slow and what is fast?
  - It relates to the natural “scale” or the time constant or the frequency.

Experimental Determination of Dynamic Performance Parameters

- Determine the time constant:
  - Apply step-function input.
  - Determine the time to reach 63% of the steady state value.

- This approach is practical only under ideal conditions.
  - If the data is noisy or if the data are missing in this critical time period, the method fails.

- What do we do?
  - Better to apply other methods
  - Linear regression method