Letters to the Editor

Comments on "The Determination of Time Constants of Reactor Pressure and Temperature Sensors: The Dynamic Data System Method"

In a recent paper[1] Wu et al. used autoregressive moving average (ARMA) models to estimate time constants of pressure and temperature sensors. This Letter seeks to clarify an uncertainty in the determination of time constants, which the authors did not discuss in their article.

A fundamental limitation in the cases described by the authors is that only the sensor *output* signal was available; the sensor *input* signal was not available. When the sensor input signal is not known, it is impossible to determine the dynamic characteristics of the sensor directly from the sensor output signal.

While the authors' ARMA method does provide an estimate of what they call "system dynamics," their system dynamics includes not only the sensor dynamics but also the "dynamics" of the sensor input signal if the input signal is not white noise.[2]

Since the nonwhite characteristics of the sensor input signal, as well as the sensor dynamics, are included in the ARMA model estimation of the system dynamics, the sensor dynamics must (somehow) be separated from the input signal characteristics. To do this, the authors assume that a certain root of the ARMA model is associated exclusively with the time constant of the sensor. However, the authors have not demonstrated that an ARMA model root can be associated with a single dynamic root (time constant) of a system.

Their test cases suggest that one ARMA model root could be associated with the time constant. However, the test cases all involved systems driven by the required white noise. Therefore, the test cases do not provide a true test of the methodology employed with the real sensor signals.

In conclusion, since the nature of the sensor input signal was not established, the sensor dynamics cannot be determined reliably. Any method using only the sensor output signal must face this problem. The problem arises specifically in the ARMA-model method when distinguishing between the system dynamics, measured by the ARMA model and the sensor dynamics, since the system dynamics consists of characteristics of the input signal plus the sensor.

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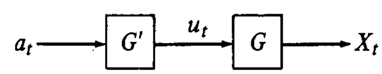
[1] S. M. WU, M. C. HSU, and M. C. CHOW, *Nucl. Sci. Eng.*, **72**, 84 (1979).

[2] G. E. BOX and G. M. JENKINS, *Time Series Analysis: Forecasting and Control*, p. 46, Holden-Day, Inc., San Francisco, California (1976).

Response to "Comments on 'The Determination of Time Constants of Reactor Pressure and Temperature Sensors: The Dynamic Data System Method' "

In response to the remarks of Mullens[1] to our paper,[2] it is true that it is impossible to determine the dynamic characteristics of the sensor only from the sensor output signal by conventional frequency analysis. However, the dynamic data system (DDS) approach can find these characteristics by output alone. In the case of white noise input, the dynamics contained in the autoregressive moving average (ARMA) model can be related to the output. If the input, u_t, is nonwhite, then the input signals can be decomposed into two parts G', the dynamic part, and the white noise, a_t, as follows,



,

where

a_t = white noise

u_t = nonwhite system input

X_t = system output

G' = transfer function of input mechanism

G = transfer function of system.

As long as there is no pole-zero cancellation between G and G', then the dynamics of input, G', will show up in the DDS model with a valid root. The problem of identifying which modes of dynamics belong to the system can be resolved from the interpretation or *a priori* knowledge of the system.

In the identification of the sensor's time constants, the open loop system model is assumed. If the system is a closed loop, then there may exist feedback effects in the DDS model. There are two methods that can be applied if the input variable is measurable: one, by the use of the bivariate DDS modeling; the other, by the use of the modified univariate DDS modeling (through pre-whitening). Therefore, there are two cases where the DDS could fail. One is nonwhite input with pole-zero cancellation with input unmeasurable; the other is the closed loop system with input unmeasurable.

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[1] J. A. MULLENS, *Nucl. Sci. Eng.*, **76**, 79 (1980).

[2] S. M. WU, M. C. HSU, and M. C. CHOW, *Nucl. Sci. Eng.*, **72**, 84 (1979).