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AUTOMATED PATTERN RECOGNITION SYSTEM FOR NOISE ANALYSIS*

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A pattern recognition system was developed at ORNL for on-line monitoring of noise signals from sensors in a nuclear power plant. The system continuously measures the power spectral density (PSD) values of the signals and the statistical characteristics of the PSDs in unattended operation. Through statistical comparison of current with past PSDs (pattern recognition), the system detects changes in the noise signals. Because the noise signals contain information about the current operational condition of the plant, a change in these signals could indicate a change, either normal or abnormal, in the operational condition.

The system begins operation in a "learning" mode, during which a sufficient number of PSDs of each signal are measured to determine the "baseline" PSD and its statistical variations. The length of the learning period, selected by the noise analyst, is usually several hours.

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After the learning period, the system begins the surveillance mode in which measured PSDs are statistically compared with previously learned (baseline) PSDs to determine whether the measured values are within expected statistical variations. If they are not, the PSDs are stored for later analysis by a noise analyst. (The statistical methodology developed to determine the statistical similarity of PSDs is described in ref. 1.)

Because normal changes during operation of a plant can affect the measured PSD of the noise signal from a sensor, the system is equipped to characterize, or "label," an operating state, as follows. Selected plant process signals (e.g., temperatures, pressures, flows) are monitored. Ranges of these signals are predetermined to define normal operating states (e.g., a reactor power level). If one or more of these signals should indicate a change to a new normal operating state, the pattern recognition system will interrupt the monitoring mode and initiate the establishment of new baseline PSDs before it allows monitoring to be resumed. This feature reduces the storage of PSDs initiated by changes in the normal operating state. Alternatively, if baseline PSDs are already available for the new operating state, the system can use them without relearning.

To prevent a change in the performance of the pattern recognition system from falsely indicating that the measured PSDs have changed, each signal channel is equipped with a special test signal input. The controlling computer selects this signal both periodically and whenever anomalous PSDs appear in the plant sensor signals. Correct recalculation of the known test signal PSD verifies that the system is operating properly.

The system (Fig. 1) includes a DEC PDP-11/34 minicomputer with 32K words and two disks of 1.2M words each. It has sixteen input channels, three with differential amplifiers having a computer selectable gain. Antialiasing, low-pass filter settings and amplifier input mode (ac or dc coupled, sensor signal or test signal input) are also computer selectable.

The system was demonstrated at an ORNL research reactor (High Flux Isotope Reactor) by continuously monitoring the noise signals from two neutron detectors through four reactor fuel cycles of 22 d each. Fourteen process signals were logged to label the operating state. The neutron noise signals were analyzed in two frequency ranges: 0.25 to 14 Hz, with a resolution of 0.125 Hz; and 14 to 55 Hz, with a resolution of 0.5 Hz. The learning period was ~3 h. After a software error which appeared during the first fuel cycle was corrected, the system operated continuously for 288 h and acquired nearly 13,000 PSDs of the neutron noise signals. Of these, 434 were "flagged" as representing detected changes in the sensor signals, and, hence, they were stored for later perusal.

During the second fuel cycle, the system operated continuously for >400 h (except during a midcycle reactor shutdown). System operation was unattended (except for an occasional check to assure that the system was running). Approximately 42,500 PSDs were measured, with 595 stored for further analysis. Although the normal PSDs were not stored, they were statistically similar to the baseline PSD which is stored. Since the system kept an account of the number of normal PSDs which occurred between the abnormal ones, a noise analyst can make use of all of the several thousand PSDs measured by the system in reconstructing the time history of the noise signals during a fuel cycle. A further demonstration of the system in an operating power plant is planned this year.

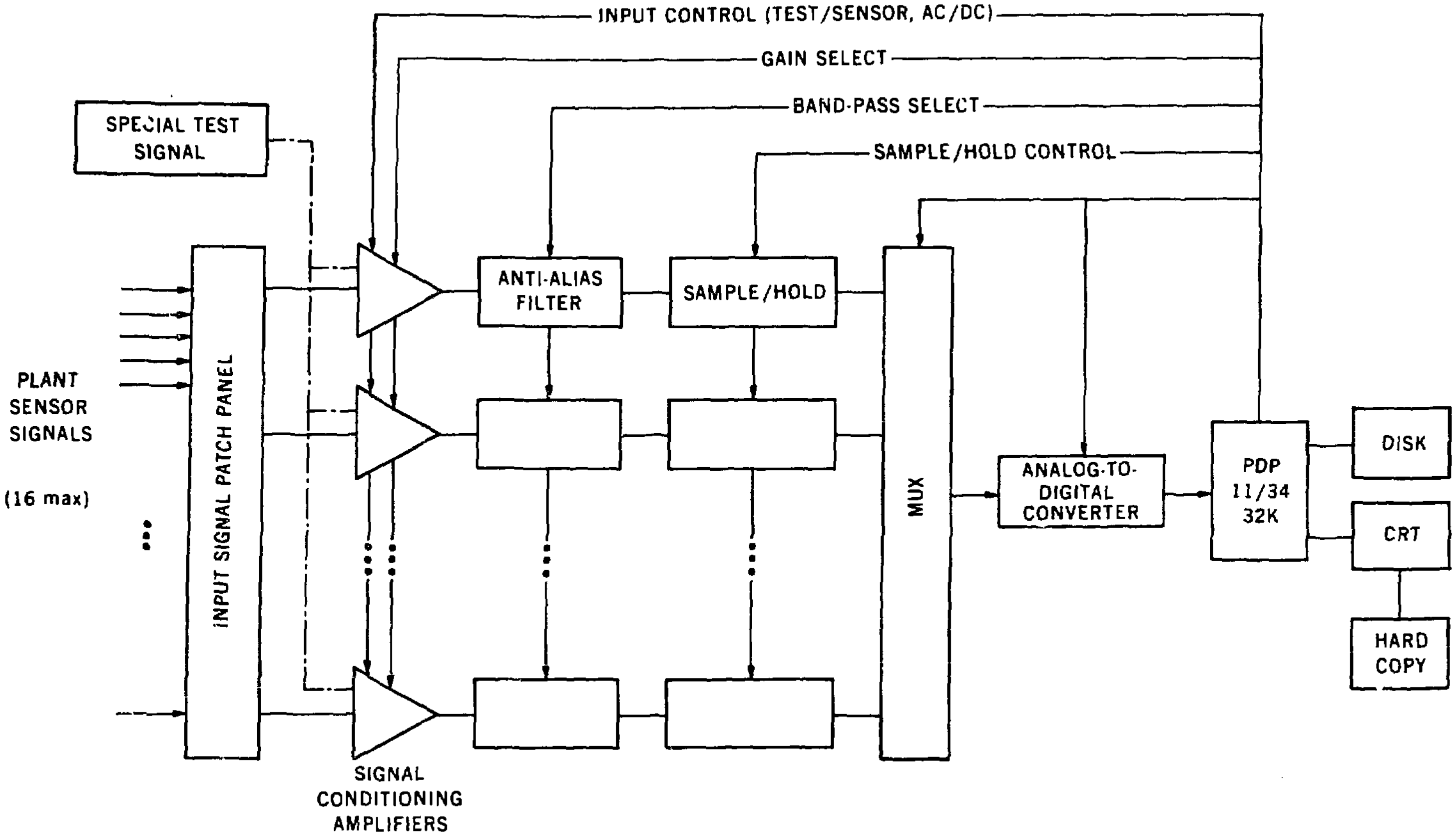
The pattern recognition system provides a means to obtain, on-line, the long-term characteristics of plant sensor noise signals, documented in concise form, with unattended operation. The capability to obtain such a body of documented PSDs by an automated system has not been available heretofore.

REFERENCE

1. K. R. Piety, *Prog. Nucl. Energy* 1 (2-4), 781 (1977).

FIGURE CAPTION

Fig. 1. Diagram of pattern recognition system.


INPUT CONTROL (TEST/SENSOR, AC/DC)
GAIN SELECT
BAND-PASS SELECT
SAMPLE/HOLD CONTROL
SPECIAL TEST SIGNAL
PLANT SENSOR SIGNALS
(16 max)
INPUT SIGNAL PATCH PANEL
ANTI-ALIAS FILTER
SAMPLE/HOLD
MUX
ANALOG-TO-DIGITAL CONVERTER
PDP 11/34 32K
DISK
CRT
HARD COPY
SIGNAL CONDITIONING AMPLIFIERS