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SURVEILLANCE APPLICATION USING PATTEN RECOGNITION SOFTWARE AT THE EBR-II REACTOR FACILITY

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Denny L. Olson
IFR Operation Division
Argonne National Laboratory
P.O. Box 2528
Idaho Falls, Idaho 83403-2528, U.S.A.

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ABSTRACT

The System State Analyzer (SSA) is a software based pattern recognition system. For the past several years this system has been used at Argonne National Laboratory's Experimental Breeder Reactor II (EBR-II) reactor for detection of degradation and other abnormalities in plant systems. Currently there are two versions of the SSA being used at EBR-II. One version of SSA is used for daily surveillance and trending of the reactor delta-T and startups of the reactor. Another version of the SSA is the QSSA which is used to monitor individual systems of the reactor such as the Secondary Sodium System, Secondary Sodium Pumps, and Steam Generator. This system has been able to detect problems such as signals being affected by temperature variations due to a failing temperature controller.

INTRODUCTION

It is imperative that the engineers and operators of a nuclear power plant be aware of the changing plant parameters and individual signal changes or failures in the plant systems. The SSA is being used as an engineering surveillance tool at Argonne National Laboratory's EBR-II reactor to provide this type of information. The SSA has proven to be both useful and flexible in daily surveillance to detect plant system changes and individual signal changes or failures. It is also being used for detection of long term degradation and other abnormalities in plant systems. The SSA is used for surveillance of the Intermediate Heat Exchanger (IHX), reactor delta-T, primary sodium pumps and several other plant systems. This paper describes the SSA and results of current applications at the EBR-II reactor facility.

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SYSTEM STATE ANALYZER DESCRIPTION

The SSA is a software-based pattern recognition system that learns pattern relationships from previously established signals from the plant data acquisition system (DAS) and compares them to current signal values during normal plant operation. This comparison is used to detect abnormalities in signal patterns in the plant. The SSA uses learned patterns from a of group signals that best represent the system or component to be monitored. It uses learned patterns to monitor and detect variations from expected relationships over a period of time specified by the user. The SSA identifies system or component states that occur over the learned period and identifies the learned states that the new data patterns most closely match. The new estimated state established by the SSA takes into account the similarities with the previous learned states. The estimated state contains new values for every parameter being monitored.

The SSA uses two methods for displaying information to the operator . Shown in figures 1 and 2. Fig. No. 1 is a signature plot showing a list of actual signals at a specific time. The horizontal line in Figure 1 represents the SSA prediction. The vertical bars represent an ordered progression of the normalized values of individual signals. The bars on the left side indicate signals that are higher than the estimated values, and the bars on right side indicate signals that are lower than estimated values. The distribution is shown from left to right showing in descending order those signals that deviate the most in the positive direction on the far left, crossing over the horizontal line near the center indicating signals that closest to the estimated values and continuing to the right with signals that are lower than the estimated value. The two vertical lists of numbers indicated those signals that are farthest from their estimated values. The percent average deviation is printed above the graph in the center.

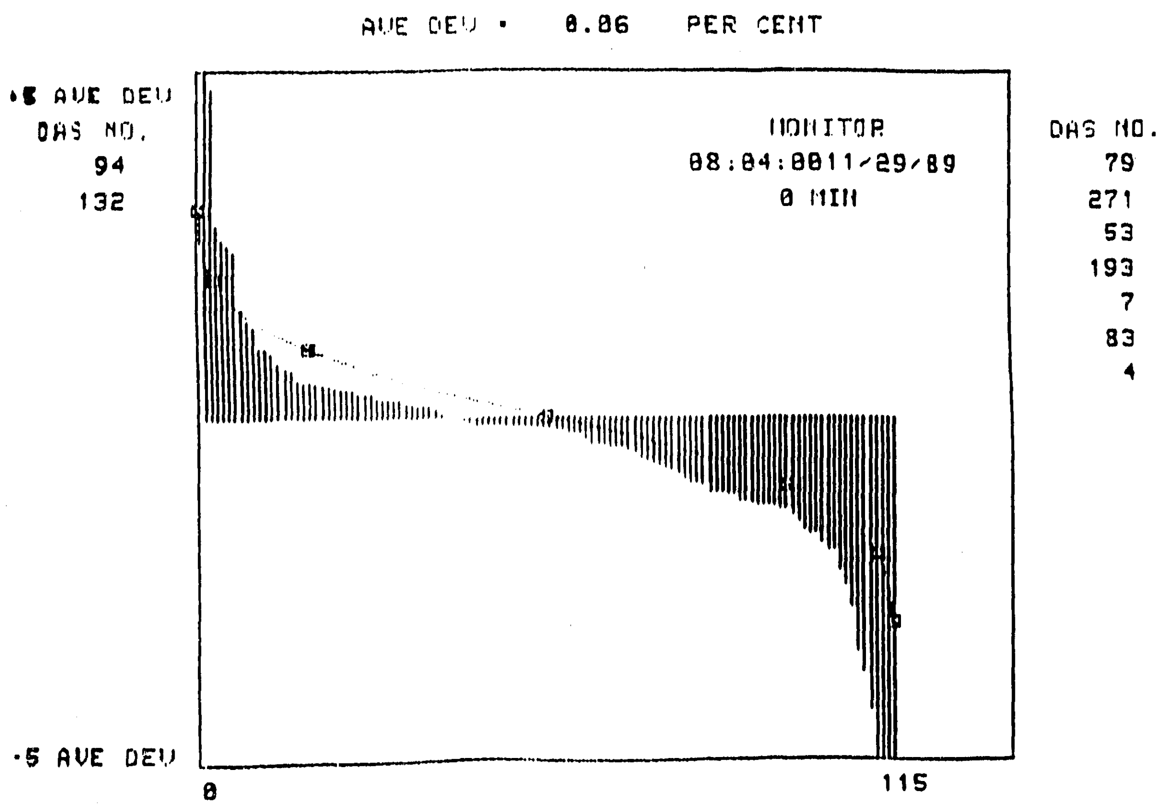

Figure 1. SSA Signature Plot

Fig. No.2 is an individual signal plot or time/history plot. This graph shows DAS channel 327 Average Bulk Sodium Temperature drifting from its estimated value. The upper and lower uncertainty boundaries are shown above and below the SSA estimated value representing the degree of uncertainty at each data point. When the signal value deviates from the estimated range the uncertainty boundaries begin to widen indicating that there is a potential problem developing in the signal parameter being measured or that the signal is degrading, which requires further investigation of other plant parameters that are closely related to the signal being shown.

Another example of daily surveillance using the on-line version, was a problem with DAS channel 133 IHX Outlet Yard Pipe Temperature. This was detected by observing the individual signals listed on a signature plot such as the one shown on Fig.1. After detecting the problem the system engineer notified the reactor maintenance personnel. The cause was a loose thermocouple connection to the IHX outlet yard pipe.

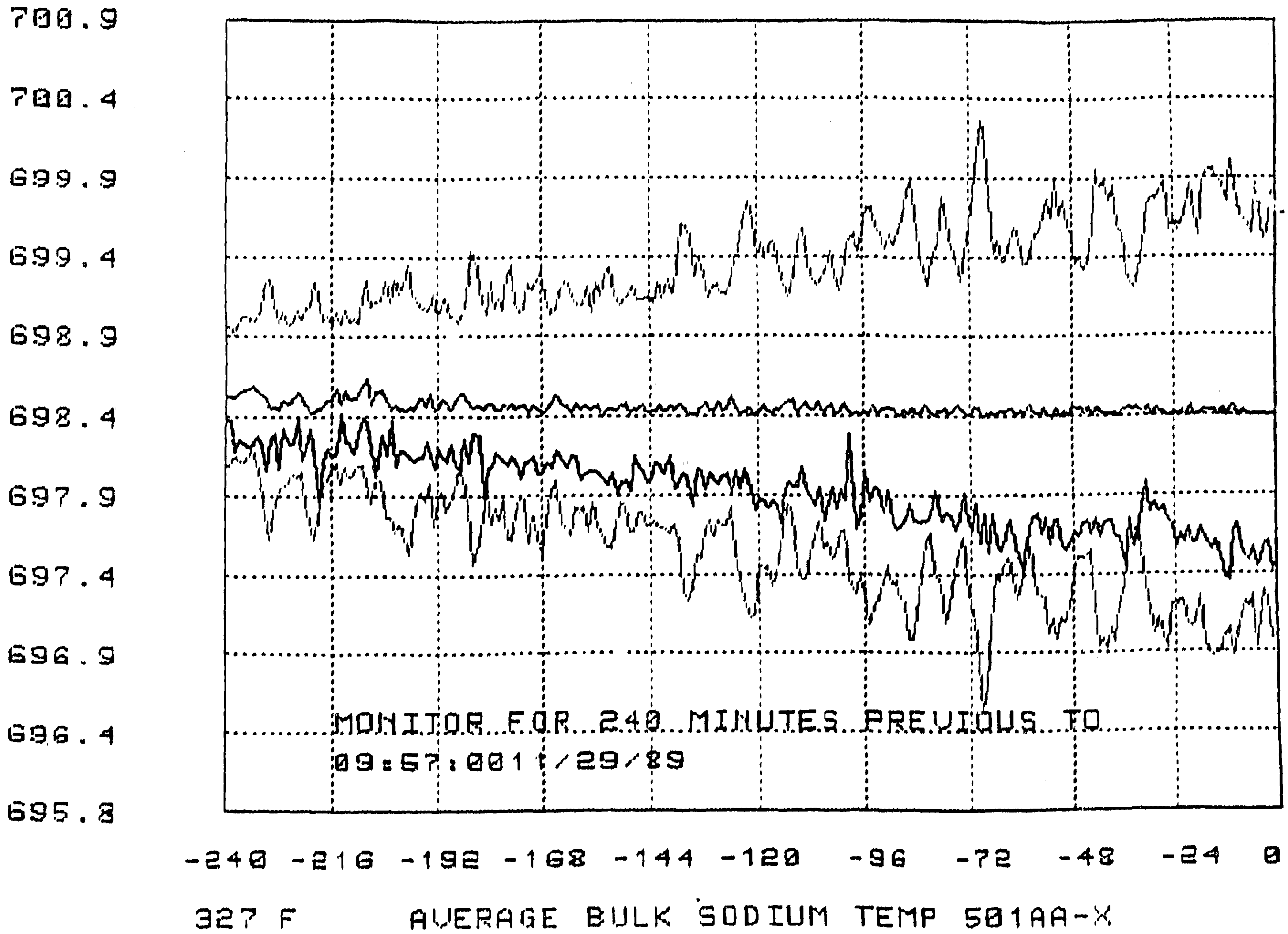

Figure 2. SSA Individual Signal Plot

DESCRIPTION OF APPLICATIONS AND USAGE

Currently two versions of the SSA are being used as engineering surveillance tools. Currently the most used version of the SSA is the on-line version. This is run using a Tektronix 4107 terminal linked to the EBR-II Data Acquisition System (DAS). Surveillance is performed daily looking at the reactor delta-T signals. A signal map consisting of approximately 115 DAS channels representing reactor power, temperatures, and flow channels is used. A learned state is used from the previous reactor run to observe any changes or abnormalities from run to run. Learned states are captured at different times during a run and used to monitor and evaluate variations within the run. Daily surveillance is performed by recording the individual channels that are listed on each side of the graph as shown in Fig 1. The engineer looks at the individual channels to determine if the signals are outside of the uncertainty boundaries and, if so, what is causing this change. Throughout the day the engineer observes the signature plot screen to see if the number list has changed from the time he had recorded the previous data. If the number list has changed he then looks at each DAS channel again to determine its cause. If a signal is failing or failed he alerts the responsible systems engineer or the reactor supervisor. This version has been used to track reactor transient tests and is used to track reactor startups.

Figure 3. is a individual signal plot that shows how the SSA estimated value tracks with the actual DAS signal at each power level during a reactor startup. The learned state is used from previous reactor startups to look for signal correlation and any deviation from the previous startup. Data is taken at the 30 mw power level and stored in a DAS file for future use.

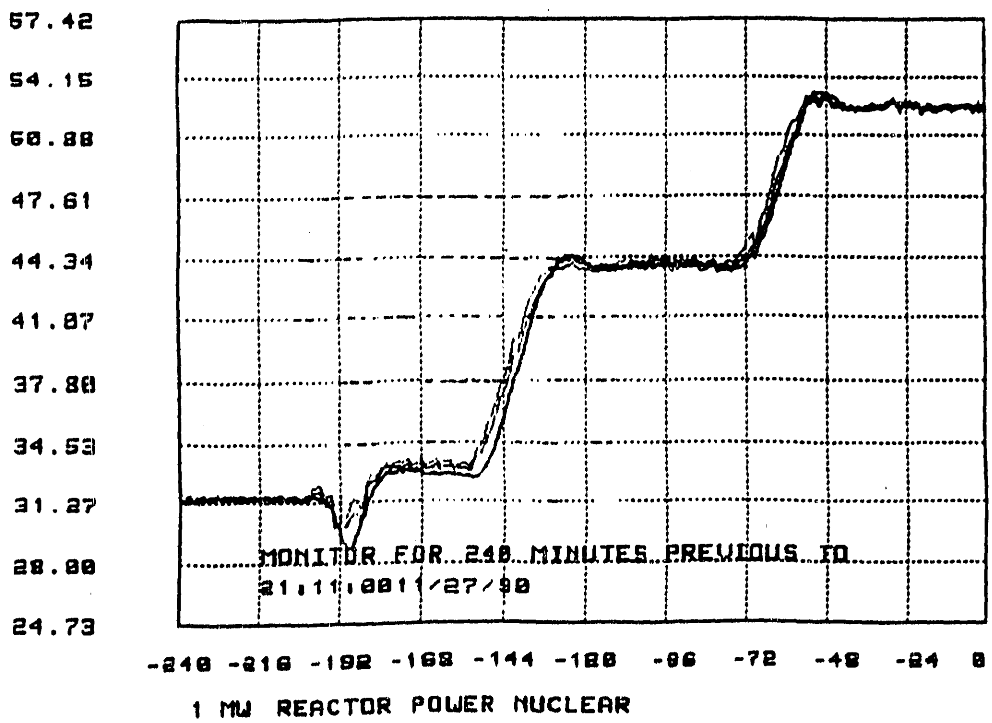

Figure 3. Individual Signal Plot of Reactor Startup

The second version of the SSA is the off-line version known as QSSA. It is run on any personal cpu that can be linked to the Data Acquisition System this system is used to gather data once a week. Separate DAS channel maps were developed to monitor each system such as the Secondary Sodium System, Steam Generator, and the Secondary Sodium Pumps. A library of learned states and previous run information is being kept for future use to look for system or plant degradation. In conjunction with the QSSA is a program called Extended System State Analyzer Program (ESSAEP). This program allows the user to enter data into a monthly file that can be identified for later use. For example, all data processed during the month of January 1991 will be put into a file named Jan91.DAT. This information can then be used to display a history of any parameter as actual, predicted, deviation from predicted, or percent deviation from predicted. Figure 4. shows a plot from which data was taken from QSSA and processed by ESSAEP. The top line represents DAS channel 53 Total Reactor Flow 541E and the bottom line represents DAS channel 47 Upper Plenum Probe Pressure 521A. As you can see the data was stored and processed for approximately six months. This ratio of the two channels shows that the correlation was drifting apart until about mid-March, after which a temperature controller was replaced during a scheduled reactor maintenance shut down. After the controller was replaced the two signals once again began to track very well. This information is one example of how information stored in the system can be used to detect and correct equipment problems.

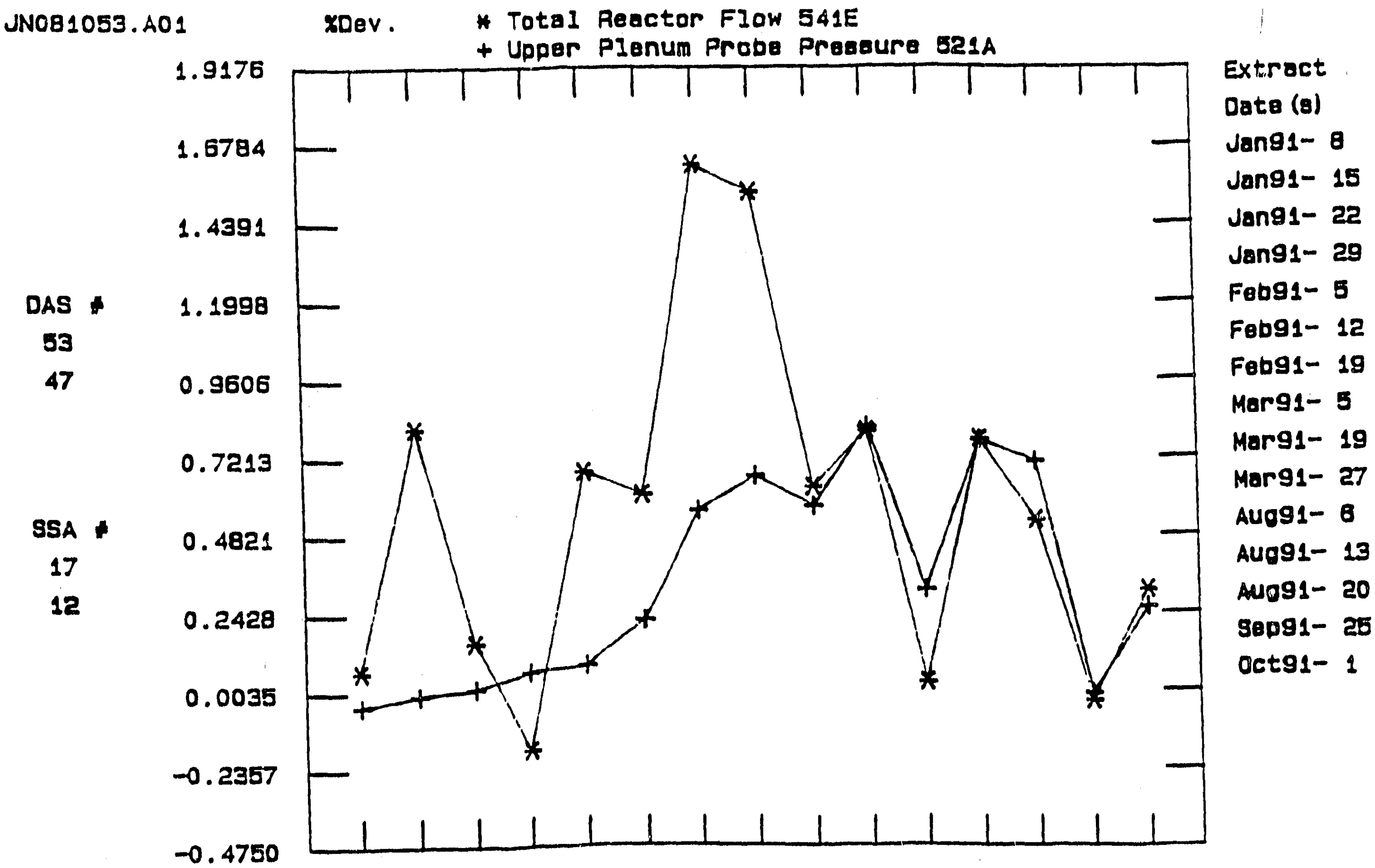

Figure 4. Line Plot

A third version of the SSA is still under development and checkout. It will be used to monitor core temperature rise on-line. This version is written in "C" language which runs in near real time. The system is installed on dual 80386-based microcomputer system and produces delta-T signals every one second. Data for the SSA system will be supplied to both computers simultaneously from DAS, but only one supplies the input variables. The other computer acts as a signal validator and process monitor. A learned library from each reactor run is being kept using this system to monitor reactor delta-T.

CONCLUSION

The SSA is a product of years of research and development and has proven its usefulness several times, during plant surveillance when degraded instruments have been detected and off-normal conditions have been diagnosed. Refinements continue to be made to the SSA, and we hope to make it useable as an operator aid in the control room in addition to increased application as an engineering surveillance tool.

REFERENCES

1. R.W. King, W.H.Radtke, J.E.Mott "Pattern-Recognition System Application to EBR-II Plant-Life Extension," Proc. ANS Topical Meeting on Nuclear Power Plant Life Extension, Snowbird, Utah, 1988.

2. R.W. King and R.M. Singer, Development and Application of Diagnostic Systems to Achieve Fault Tolerance, "Seventh Power Plant Dynamics, Control and Testing Symposium, Knoxville, Tn, 1989.

3. J.D. Staffon, Digital Feedwater Control Utilizing Pattern Recognition Software,"ANS International Topical Meeting on Safety, Status and Future of Non-Commercial Reactors and Irradiation Facilities" Boise, Idaho 1990.

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