Abnormal Signal Analysis for a 4~20mA Equivalent Circuit Regarded as High Temperature Accident Conditions

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1. Introduction

Generally, high-temperature heat is generated within a containment building of a nuclear power plant by a severe accident due to direct heat, design basis events, or a loss accident of an air cooling apparatus, etc. The high heat generated directly or indirectly affects the inside of the containment vessel as well as the instrument circuit. A physical change in the instrument circuit due to these accidents makes an open circuit, a ground circuit, or a short circuit, and the like, an extreme state going through an incomplete transition state, wherein error information can be input due to an abnormal signal in a transient state exceeding instrument environmental conditions and design range and judgment errors can be caused due to the error information. Therefore, a need exists for analysis methods and analysis apparatuses capable of quantitatively analyzing the causes of the failure circuits from the error information through a transient signal analysis technology, under a degradation condition in circuit elements due to the physical change in the instrument caused by the high-temperature environment that is the severe accident affecting the nuclear power plant. In the case of an abnormal signal level from an instrument under a severe accident condition, it is necessary to obtain a more accurate signal validation to operate a system in a control room in NPPs.[1-2] Diagnostics and analysis for some abnormal signals have been performed through an important equivalent circuits modeling for passive elements under severe accident conditions[3-5]. In this paper, the present technology relates to abnormal simulation signal analysis methods and abnormal signal simulation analysis module for 4~20 ㎃ instrumental system capable of grasping and improving error causes through an abnormal signal analysis after configuring a simulation equivalent circuit for a 4~20 ㎃ instrument unsatisfied in a temperature environmental impact assessment.

2. Design for a Abnormal Signal Simulation Analysis Module

In order to accomplish the technical problem, the present technology relates to abnormal simulation signal analysis methods and abnormal signal simulation analysis module for 4~20 ㎃ instrument unsatisfied in a temperature environmental impact assessment, the abnormal signal simulation analysis module includes : a circuit simulator module capable of configuring a simulation equivalent circuit of the instrument and obtaining an output signal by inputting a negative pulse; an analysis module receiving the output signal output from the circuit simulator module and then analyzing it; and an abnormal simulation signal analysis module including a system linking module that links the circuit simulator module to the analysis module. The system linking module has a one body code order system. The circuit simulator module and the analysis module on the system linking module can be changed, the circuit simulator module includes a function of estimating variation of time constant of the equivalent circuit according to variation of temperature. The circuit simulator module includes a function of estimating variation of element according to the variation of time constant, includes a function of analyzing accident conditions of the instrument according to the variation of element. The analysis module includes a function of classifying and assessing the instrument in an abnormal condition according to a result of a survivability assessment method and a function of validating a signal processing result. In another aspect of the present technical method, the present technical method relates to a signal analysis method for 4~20 ㎃ instrument unsatisfied in a temperature environmental impact assessment, the signal analysis method includes: a first step of configuring a simulation equivalent circuit of the instrument; a second step of obtaining an output signal by inputting a negative pulse to the equivalent circuit; a third step of receiving the output signal output from the second step and analyzing it. The first to third steps are performed according to a one body code order system.

The second step includes a second-first step of estimating variation of time constant of the equivalent circuit according to variation of temperature. The second step includes a second-second step of estimating variation of element according to the variation of time constant. the second step includes a second-third step of analyzing accident conditions of the instrument according to the variation of element.

The third step includes a third-first step of classifying and assessing the instrument in an abnormal condition according to a result of a survivability assessment method. The third step includes a third-second step of validating a signal processing result. The third step includes a third-third step of directly connecting to meters installed on the spot. In still another aspect of the present technical method, the present technical method provides a recording medium readable with a computer in which a program for realizing the aforementioned abnormal simulation signal analysis method is stored.

3. Data Simulation and Response Characteristic Analysis

3.1 Defining the Signal from the Equivalent Circuit

Input reference signal was defined in the engine code as a piecewise linear approximation, having a 0-16mA pulse with a 0 ms delay, 30ms rising time, 30ms falling time, and a 1PPS repetition rate. It describes an output current pulse as measured across the current to voltage converter at the receiver. This is a reference input current I [A] and the output volt V [V] data of the pulse parameter as an initial value. In this figure 1, it appears as a 0.2 to 1.0 [V] pulse at the temperature of 27 [C] as a normal temperature condition.

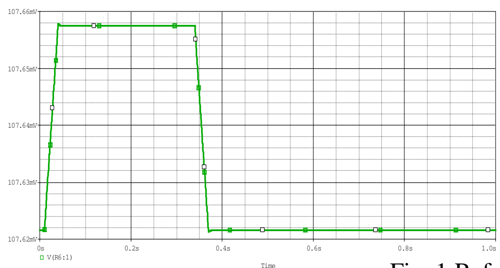

Fig. 1 Reference input voltage at the temperature of 27 °C

3.2 Response Characteristic Analysis of the Signal for a change of the R2, C1

In that case, output data for the pulse parameter for a change of the resistance R2 can be analyzed.

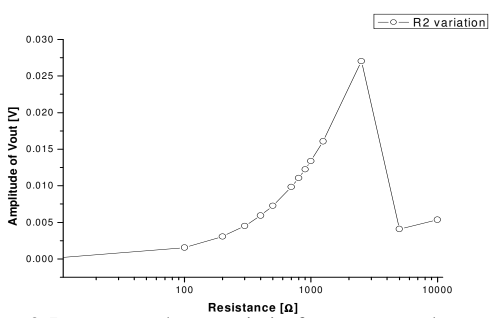

Fig. 2 Response characteristic for output voltage of the pulse parameter for a change of the resistance R2

Figure 2 shows the response characteristics of the output voltage for the pulse parameter according to a change of the resistance R2 which range has 5[Ω]~10[kΩ]. In the case of the R2 simulation by using the tool code, it can be seen that the resistor value changes at high voltage levels which means a good linearity (sensitivity) response characteristic over 1[kΩ] to 2.5[kΩ], but in the case of over 2.5[kΩ] they have a nonlinearity response characteristics, in the case of an overall response characteristic with an increasing response characteristic for an increasing resistance. The slight offset from these values on the plots is because of an error caused by a circuit simplification, which it is not considered as significant. In that case, output data for the pulse parameter for a change of the capacitance C1 can be analyzed.

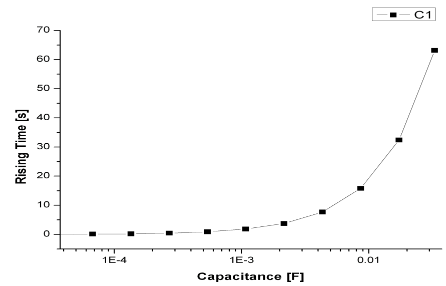

Fig. 3 Response characteristic of the rising time [Tr] of the pulse parameter for a change of the capacitance C1

Figure 3 shows the response characteristics of the rising time [Tr] for the pulse parameter according to a change of the capacitance C1 which range has 33[nF]~33[mF]. The response characteristic of the rising time [Tr] for the pulse parameter, which means a good linearity (sensitivity) for the response characteristics over the same range, in the case of an overall response characteristic reveals an increasing response characteristic for an increasing capacitance C1**.**

4. Conclusion

Using the ASSA(Abnormal Signal Simulation Analysis) module system, we could obtain the response characteristic from the output voltage levels of a pulse parameter according to a change of the resistance for R2 and the response characteristic from the output voltage levels and time constant of the pulse parameter according to a change of the capacitance for C1. For the case of the pulse parameter following a change of the resistance, we obtained good response characteristics for the output voltage levels. For the case of the pulse parameter following a change of the capacitance, we could obtain much better response characteristics for the output voltage levels including the time constant patterns.

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