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On expected detection delays for alarm systems with deadbands and delay-timers

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ABSTRACT

False and nuisance alarms are major problems in the process industry. Techniques like deadbands, delay-timers, and filtering can significantly reduce these false and nuisance alarms. The down-side, however, is that using these techniques introduces some delay in raising the alarm (detection delay). The detection delay is not often considered in the design of alarm systems. In this paper, detection delays are calculated using Markov processes for deadbands and delay-timers. A design procedure is then proposed that compromises between detection delay, false alarm rate (Type I error) and missed alarm rate (Type II error) for an optimal configuration. Inclusion of the detection delay in the alarm design makes the design more reliable and provides better insight to the consequences.

1. Introduction

In any industrial setup, the most desired feature is smooth and uninterrupted operation of the plant. Modern industries are therefore monitored by hundreds and thousands of sensors. These sensors are installed in different areas and they communicate through a medium to monitor physical or environmental conditions of the plant. Under fault-free operating conditions the operator carries out routine actions. Whenever a process variable exceeds some certain threshold an alarm is raised to indicate abnormality. Operators are informed of any problem by alarms indicating abnormal behavior of the plant. To ensure cost efficiency, safety of the work force and plant, and quality of products, faults must be identified promptly and appropriate actions should be taken as soon as possible. Failure in such actions may result in serious consequences, even human injuries and casualties. With virtually every aspect and location of the systems being monitored, the probability of an event going undetected is very low. Furthermore, the consequences of any nontrivial event are likely to be picked up independently by several sensors and reported in separate alarm messages causing nuisance alarms. It gives a false impression about the nature of fault to the operator. Working under such a stressful environment, the performance level of operators can go down causing serious consequences in responding to a true alarm. In 1994, 11 min prior to explosion in the Texaco Milford Haven Refinery, the two operators had to recognize, acknowledge, and act on 275 alarms [1]. Therefore efficient alarm management is very important for safe operation of the plant.

There are several methods for fault detection as discussed in [2–5]. These detection techniques can be broadly classified into two categories: model-based, and signal processing based. Compared to signal processing based, model-based fault detection is a more active area in the field of control theory and engineering [5]. However, for most practical systems it is difficult to obtain precisely known mathematical models [2] or they are highly nonlinear and not feasible for implementation from economic point of view. Therefore the application of the model-based scheme is limited. Furthermore, model creation is a time-consuming task and it is not always certain that the model will be valid; a created model is also required to be revised if changes are made in the process [6].

The most common and frequently used fault detection method in industry is simple limit checking of a directly measured variable (signal processing based fault detection) [2,6]. This method has the advantages of simplicity and ease of implementation. However, a problem with this simple technique is proper selection of

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