A Study on Preemptive Response to Equipment Problems in Public Address System

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ABSTRACT : In this study, in preparation for equipment failure of emergency broadcasting equipment, we intend to propose a method to respond in advance to situations where abnormalities are visible.In the case of a short circuit in the speaker line in the emergency broadcasting system, high current from the power amplifier enters the line again and damages the power amplifier, making audio output impossible. As a method to prevent this, a method of separating the speaker line from other lines is mainly used in order not to affect other speaker lines when a short circuit occurs.In this study, a method for establishing a safety system with a higher level than the standard recommended by the government in emergency broadcasting system was studied and suggested. The method is to respond in advance by monitoring and analyzing the prognostic symptoms that appear before the actual failure occurs.For example, if a problem occurs in the system, the problem is solved by replacing the part or removing the time factor of the problem. However, before a failure occurs, there are cases in which the occurrence and cancellation of failure symptoms for a short period of time occur periodically or aperiodically. In this case, the possibility of actual failure is determined in advance by analyzing it as a precursor to the actual failure.In the event of a situation that appears to be a pre-specified potential failure, we propose techniques to diagnose it early and tell the manager how to take action.

Keywords: Public Address, Fault Tolerant System, Failure Prediction, Short Circuit Protection, Over Current, FMECA

1. Introduction

Recently, legal standards for emergency broadcasting facilities have been strengthened due to the strengthening of national disaster and fire safety standards. Specifically, according to the administrative regulations of the fire department, the following is specified in Article 5, Paragraph 1 of the Fire Safety Standard for Emergency Broadcasting Facilities (NFSC 202) [1]. 'Even if the loudspeaker or wiring of one floor is short-circuited or disconnected due to a fire, there should be no obstacle to the fire notification of the other floor.' To meet this, related industries are developing and installing equipment called 'Emergency Broadcasting Facilities Short Circuit Protection Device' to increase the output safety of emergency broadcasting systems.

The basic configuration of an audio output system consists of a power amplifier that electrically amplifies the input sound source and a speaker that receives the amplified electrical signal. At this time, the speaker serves to make the amplified electrical signal into a waveform within the audible frequency that can be heard by humans so that humans can recognize it. However, if a short circuit occurs in the speaker line of one of the multiple output speakers, a high current flows back to the power amplifier through the shorted line, in which case the amplifier usually operates its own protection circuit to protect the output circuit [2]. As a protection method, the I/O is stopped and in this case the audio output of all speakers is also stopped. This can be a catastrophic problem in systems that deliver information to an unspecified number of people, such as a public address system [3].

In the event of an emergency broadcast, for example a fire, if the broadcast is not broadcast by amplifier protection due to a short circuit, there is a possibility of injury. To prevent this, the line short-circuit protection device' only blocks the line where the short circuit occurred and outputs the audio output from the speaker on the remaining line. When emergency broadcast transmission occurs in a situation where there is a line problem, the normal output can be output to the rest of the circuit by the line short circuit protection device, but the output is not output to the problematic circuit.In this paper, we investigated how to diagnose these situations early and inform managers to take proactive action before a short circuit occurs. Prognostic symptoms often appear before system problems occur. In general, if there is a line short (fault) in the system, it can be temporarily shorted. However, whether periodic or aperiodic, short circuits and discharges appear repetitively and cause problems at critical moments [4,5].

As a way to prevent this, if such a phenomenon occurs under conditions previously specified by the user, it is judged that there is a possibility of a potential short circuit even if it is not a short circuit at the moment. Therefore, in this paper, we studied a broadcasting system with a function that monitors the manager to identify potential obstacles, informs the manager of the current situation, and warns the manager of the possibility of occurrence in advance.

2. Theory and formula

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In this study, we used the terms real and potential disability. No actual error occurred, but potential errors are expected errors. This was mainly mentioned in the concept of FMECA(Failure mode effects and criticality analysis) [6,7], one of the systematic techniques performed for failure analysis.2.1. Common fault detection

In order to determine a basic failure, the line shorting equipment monitoring unit periodically analyzes the log data accumulated in the internal DB to check whether a failure (line short) has occurred or canceled [8]. For the prediction of future failure situations, a moving average method for data of a certain period rather than data at a point in time was proposed.2.2. Potential fault detection

Even if the line short circuit device detects a failure (line short circuit or over current), it is automatically recovered, but the occurrence time lasts longer than the specified time and is judged as a potential failure when released (as shown in Figure 1).

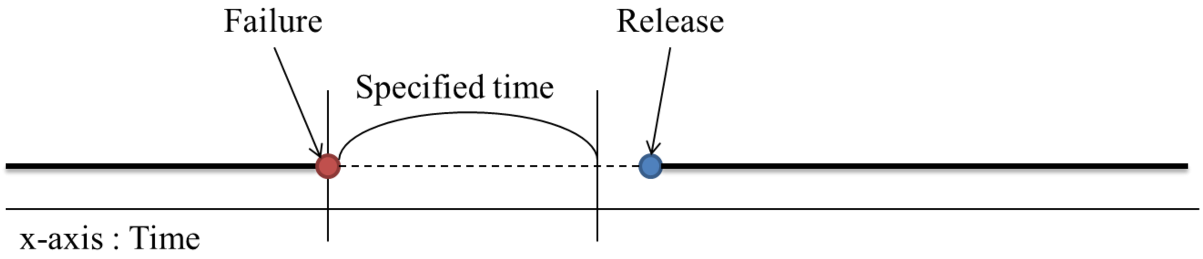

Figure 1. Judgment Criteria 1 (specified time)

If the line short circuit device detects a failure (line short circuit), even if it recovers within the specified time, it is judged as a potential failure if it exceeds the prescribed number of occurrences per day (as shown in Figure 2 below). If the short circuit occurs less than the specified time, it is judged that the event has not occurred for a certain amount of time.

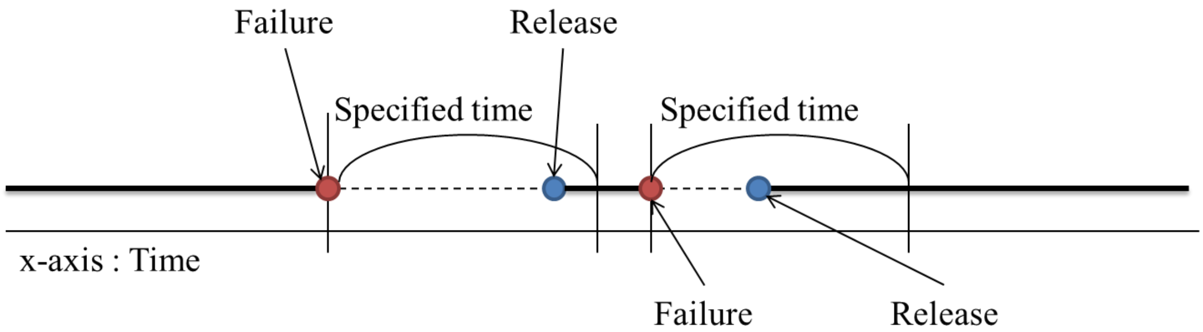

Figure 2. Judgment Criteria 2 (number of times specified)

3. Experimental setup

3.1. Fault detector

Among the failure-related design techniques in the past, there is a case of studying fault-tolerant design techniques [9-11]. In this study, it is a method of predicting a failure, not a conventional failure handling method. This allows operators to take action before a breakdown occurs. Of course, if the manager's actions are delayed, it is impossible to respond.

As shown in Figure 3, continuously checks whether an overall failure has occurred, and if the occurrence is confirmed, wait a while and check again. If the occurrence is canceled within the specified time, increase the Count and check if the specified number of times has been exceeded. (Weighted by event occurrence/cancellation time) Check if it occurs again if it does not exceed the specified number of times.

When the specified number of times is exceeded, the Count is initialized and registered as a potential error. If the error is not resolved, the user is notified with a real error in real time.

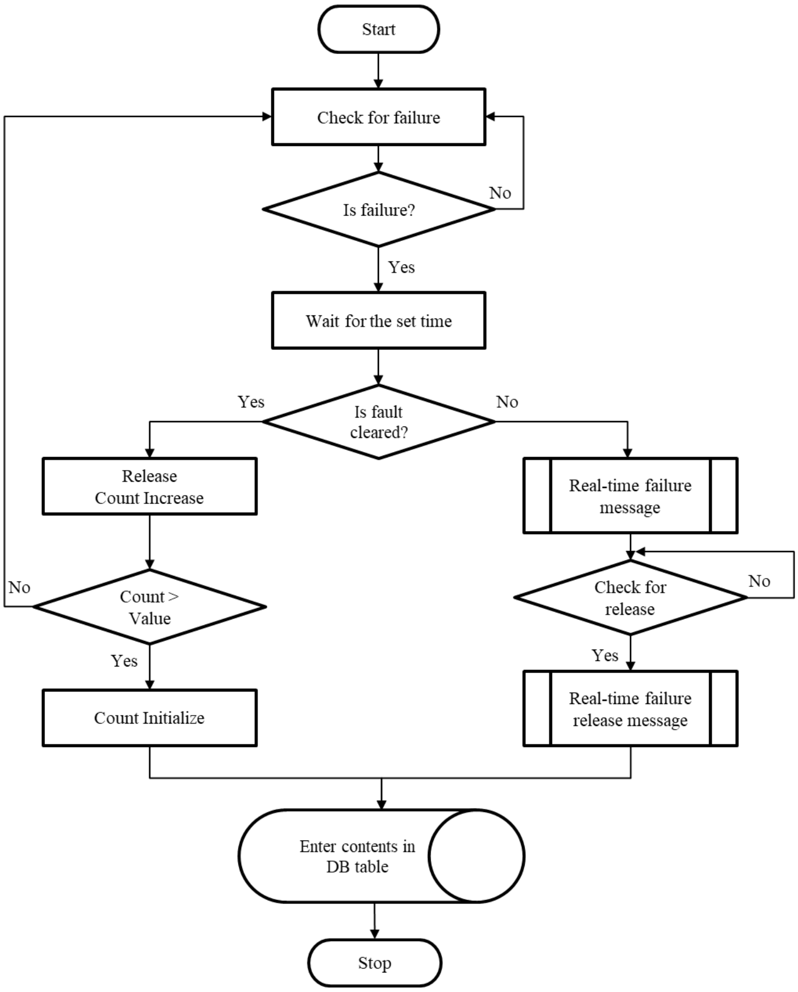

Figure 3. Potential Fault Detect

Figure 4 below is the actual log data collected by the main controller of the emergency broadcasting equipment. Here (08:58:08:838) there is a short circuit or overcurrent inside the amplifier. The fault is cleared 20ms after the occurrence (08:58:08.857).

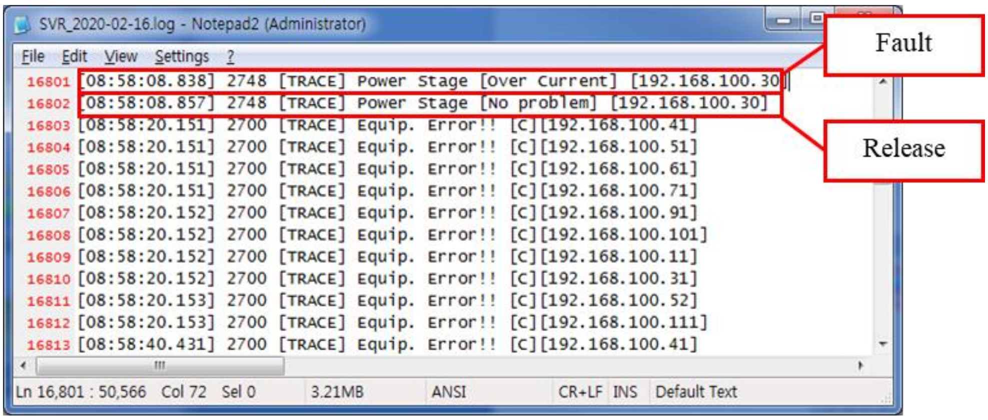

Figure 4. Real Data

3.2. Monitoring

Figure 5 below shows the flow from a condition sensing device to a monitoring device. When an abnormal (line short) event occurs between multiple lines, the abnormal information data is transmitted to the broadcast control device that can generate monitoring information through the PLC (or other communication) line.

The log is recorded in the broadcast control device. And monitor server sends monitoring information through web browser and web socket. When the screen is configured as a responsive web via Websocket, the system can be configured so that system events that change in real time are updated in the same way as the administrator's

PC screen. The web browser connects to the web server to get the screen information, but in order to display the dynamically changed content in real time, the web browser connects directly to the monitor server of the broadcast control device via the web and passes the status value.

For problems that occur as a result of real-time monitoring, the occurrence area and occurrence time values are unconditionally recorded in the occurrence information field of the DB table. Even if it is automatically released afterwards, data including time is recorded in DB.

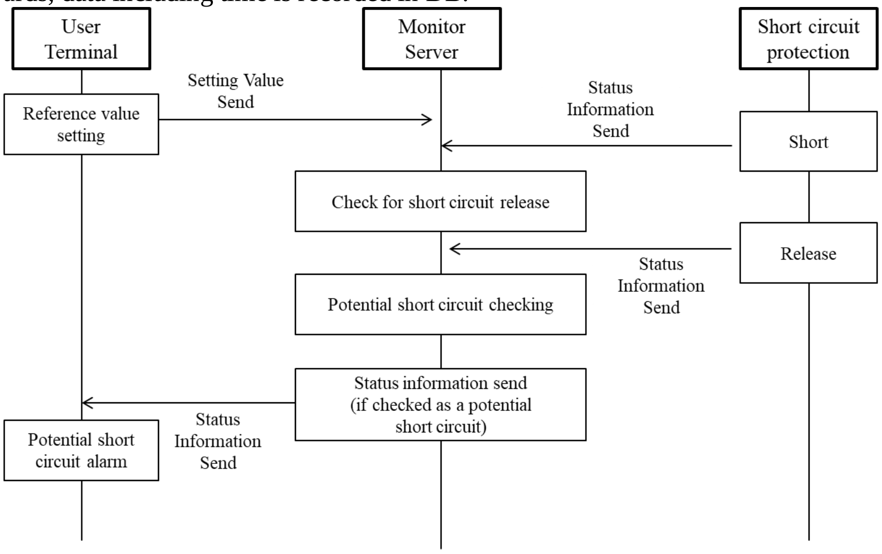

Figure 5. Process Diagram

4. Result discussions

For the experiment, log data of the power amplifier collected at the actual site for one month in February 2020 was used. This is a case where an input whose audio input level exceeds the standard (1Vrms) is continuously input to the power amplifier, and a continuous warning message is collected from the overcurrent detection sensor inside the power amplifier (as shown in Figure 6).

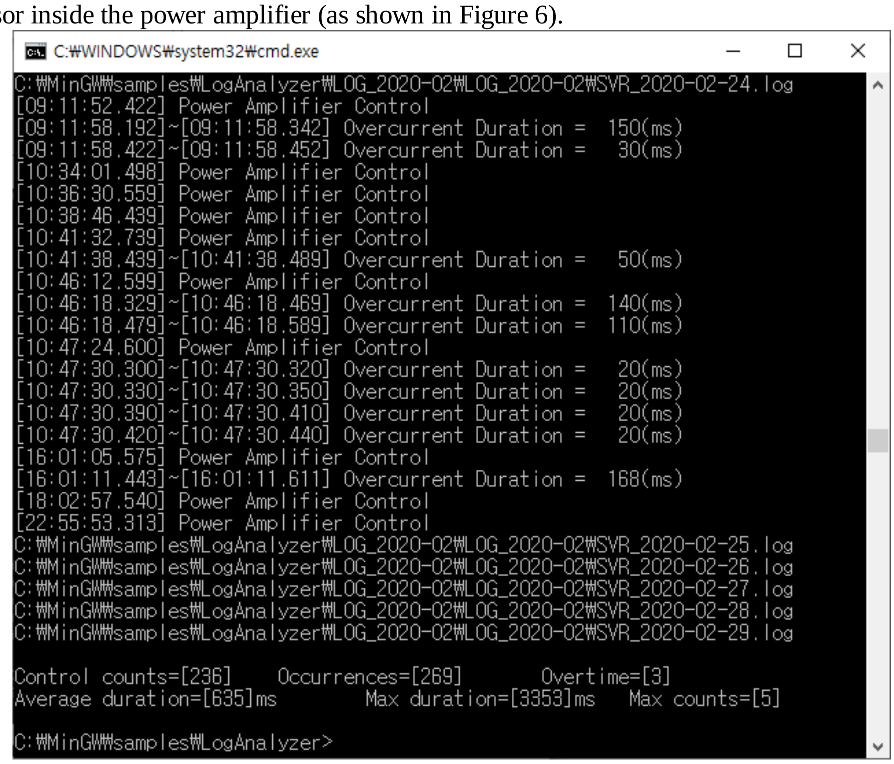

Figure 6. Test Result

The amplifier was controlled 236 times per month, of which 269 overcurrent events were detected. The reason overcurrent events occur more often than the number of controls is that an overcurrent is detected during one control and the level of the audio signal changes and falls below the judgment criterion. And then it can be judged as overcurrent again later.

Table 1. Experimental analysis result

Samples	Control Count	Occurrence Count	Overtime Count	Average duration(ms)	Maximum duration(ms)	Maximum number of times
Sample1	236	269	3	635	3353	5
Sample2	237	217	2	231	3090	4
Sample3	241	402	2	311	3087	5
Sample4	215	207	4	272	3452	3
Average	232.25	273.75	2.75	362.25	3245.5	4.25

As shown in Table 1 and Figure 6, the average time to be released after being judged as overcurrent was 362.25ms, and the maximum duration corresponding to the first judgment criteria as a potential failure was 3245.5ms. And it was confirmed on average 4.25 times for repetitive tasks that corresponded to the second criterion, which was judged as a potential failure. Therefore, if the specified time in Figure 1 is based on the experimental data, it can be judged as a potential failure if the maximum duration is more than 3500ms. And looking at the criteria of Firure2, it seems that up to 5 times can be judged as a normal operation state, and if it is more than that, it can be judged as a potential failure.

5. Conclusions

In general, in constructing a digital system, it is essential that even if a system failure occurs, uninterrupted operation must be possible in a way such as redundancy. When operating a broadcasting system, various technologies are used to prepare for failures, but in most cases, when a system failure occurs, the system is operated in a direction to minimize damage, but partial broadcast failures can be withstand. However, in safety-related systems such as emergency broadcasting, it is necessary to raise the standards for failure tolerance, monitor and analyze pioneering symptoms, and notify the manager in advance. This is well explained in 'Fire Safety Standards for Emergency Broadcasting Facilities'.

This study proposes a method of monitoring and analyzing the prognostic symptoms that appear before the actual failure occurs for these disorder situations that should be tolerated, and a method of judging this as a potential disorder and early diagnosis and notifying the manager. The method proposed in this study is expected to be applied to other industries or systems and applied in a better direction.

In this study, only research through system event data analysis was conducted in the emergency broadcasting system. However, in future research, it will be expanded to regular (weekly, monthly) reporting and analysis on the remaining life of the system through the accumulated big data analysis.

Acknowledgements

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