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Simulation of N+2 Logic for Amplifier in Railway Public Address System

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Abstract: An announcement becomes impossible if the public address (PA) system fails owing to equipment deterioration or a worker's error during construction. In this project, a study has been conducted to improve current system to provide better availability by adding two additional spare channels to the system. The amplifiers and speaker buses of the PA system are used to make the announcement. Nonetheless, the existing approach, known as N+1 redundancy, can only handle one amplifier output failure at a time. Audio announcements cannot be played from the PA system to the affected zone as long as there is more than one amplifier output channel issue. This study provides a better approach of dealing with amplifier failure. The previous approach, N+1 Switch Protection, can still be used to transfer the input to the backup channel, but in this project, the current system will be improved to accommodate a better availability of redundancy using two spare channels. This strategy improves system availability while decreasing the frequency of amplifier maintenance by adding another spare channel to accommodate N+2 redundancy. This will allow maintenance employees to repair faults in a shorter time without disrupting PA system operation during operational hours, as well as reduce the frequency of amplifier maintenance service. As a result, a complete simulation to configure the audio routing through N+2, from faulty amplifier to speaker bus is achieved.

Keywords: PA System, Redundancy, Amplifier, N+1, N+2

1. Introduction

Public address systems (also referred to as PA systems) are also categorized as a wayside system. PA systems are electronic systems that include components such as microphones, amplifiers, loudspeakers, and other similar devices to broadcast audio information. It increases the perceived

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volume (loudness) of a human voice, a musical instrument, or any other acoustic sound source, as well as the perceived volume (loudness) of recorded music or sound and are used in any public venue when an announcer, performer, or other speaker needs to be heard from a distance or over a large area. Amplification is required when a large area needs to be covered by a signal. An amplifier converts the low voltage signals from the source equipment into a signal with sufficient gain to be used to power a pair of speakers. One of the amplifiers employed in this study is the r2p Asia Sdn.Bhd. (r2p) propriety Network Audio Controller (NAC) amplifier, which has the capability of supporting up to eight amplified channels from a single NAC unit. The output channel of NAC is connected to the speaker bus and is distributed into multiple zones to ensure announcement can be made to a particular zone.

In case a single amplifier fails, the audio announcement from the PA system can still be sent to particular zone but doesn't have enough coverage to cover entire area. System needs r2p patented N+1 Protection Switch to deal with this type of situation.

N+1 was previously used in conjunction with the r2p NAC amplifier to ensure that the system remained functioning if a single amplifier output channel failed. It does have a limitation where it can only handle one amplifier output failure at a time. Typically, each zone will have at least two speaker busses/ amplifier output, so when more than one amplifier output channel fails, audio information from the PA system cannot be played to the affected zone, placing passengers in the affected zone at danger in the event of an emergency. As a result, the purpose of this project is to improve the present system by adding another spare channel (N+2) to provide better availability [1].

The objective of this project is to study the feasibility of N+2 system to detect amplifier health state. Next is to determine the logic circuit system design with N+2 system for amplifier and finally to develop simulation on designated circuit with N+2 system for amplifier.

The scope of the project is focusing on the failover system of the amplifier (N+2). The current failover system of the amplifier can only handle a single failure and this project is conducted to add another backup system for the amplifier, which is called the N+1 system. In order to demonstrate how N+2 system works, a simulation of N+2 is conducted based on the NAC, which will serve as the testing amplifier based on Binary Coded Decimal (BCD). A truth table for the logic circuit is made then the data from table is used as the parameter for simulation. Next, the simulation is done by a simulator, using Proteus, which will include the N+2 logic circuit and relay. The result of the simulation is used as the data for the project.

2. Methodology

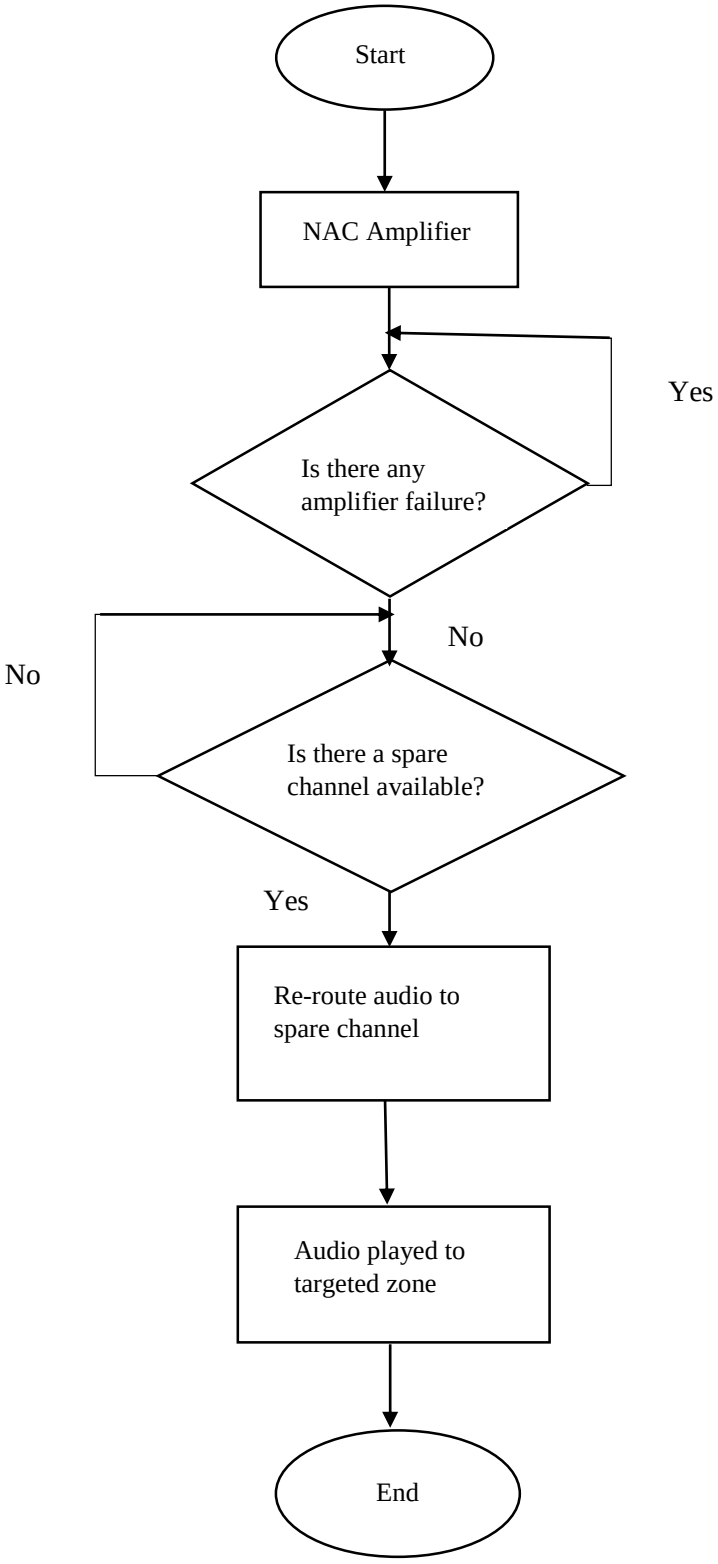

Figure 1: Flowchart of the NAC System

According to the flowchart above, the system starts with NAC sending audio to the speaker buses. Throughout the procedure, various specific scenarios may occur, such as whether an amplifier fails and whether a spare channel is accessible during the failure.

The NetSpire™ NAC system is configured to detect and respond when there is a system failure. When an event occurs in which an error is probable, such as an amplifier failing and there is no backup channel, the system will constantly check for the amplifier failure and available spare channel until the problem is resolved in a loop.

2.1 Truth table for logic circuit

A truth table is designed for N+2 system. It contains all possibilities of amplifier health states and spare channel availability (note that both spare channels are always assumed to be available). From the truth table, Boolean Expressions are listed based on the input, output and the conditions from the truth table. To route the audio from spare channel to targeted speaker bus, a 5-bit digital output signal is used to trigger the condition.

Based on the table, the inputs and outputs are shown as below.

Table 1: Input and Outputs

Inputs:	Outputs:
A - Amplifier 1 health state	J - Route amplifier 1 to spare channel 1
B - Amplifier 2 health state	K - Route amplifier 2 to spare channel 1
C - Amplifier 3 health state	L - Route amplifier 3 to spare channel 1
D - Amplifier 4 health state	M - Route amplifier 4 to spare channel 1
E - Amplifier 5 health state	N - Route amplifier 5 to spare channel 1
F - Amplifier 6 health state	O - Route amplifier 6 to spare channel 1
	P - Route amplifier 1 to spare channel 2
	Q - Route amplifier 2 to spare channel 2
	R - Route amplifier 3 to spare channel 2
	S - Route amplifier 4 to spare channel 2
	T- Route amplifier 5 to spare channel 2
	U - Route amplifier 6 to spare channel 2

2.2 N+2 simulation

The process starts with deriving the logic required to design the conditions of routing audio from a faulty channel to the available spare channel and sending specific digital output signal from the NAC to N+2 to trigger the internal relays to route the path to the targeted speaker bus.

As shown in the block diagram below, this is how the N+2 simulation will be implemented in the system.

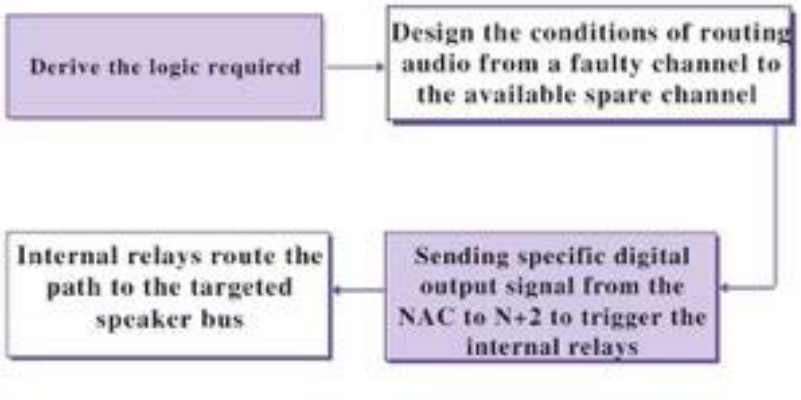

Figure 2: Flow of N+2 system

2.3 Software Used

- Proteus software:

A software used for simulating, designing, and drawing electronic circuits Circuit design on the proteus takes less time than practical circuit construction. The possibility of error is lower in software simulation, such as loose connections, which take a long time to find in a practical circuit. This software is used for simulating the logic circuit for result [16].

- Boolean expression simplifier:

A Boolean expression can be directly implemented in a logic circuit. A Boolean expression is translated to another form with fewer terms and operations using Boolean algebra simplification [12]. All the expression used to achieve the outcome of the project, which is used to trigger the output of constructed logic circuit, has been simplified using Boolean Law as example below:

N = (ABCDE'F)+(ABCDE'F')

Apply Complement Law X + X' = 1 where X = F

= ABCDE' (F+F')

= ABCDE'

Figure 3: Example of Boolean simplification

3. Result and Discussion

3.1 Logic circuit

The circuits are constructed in two versions, single circuit, and combined circuit. The single circuits show each input and output for specific scenarios and in simpler version. The combined circuit combined all the circuits including inputs and outputs for all scenarios, which has been stated in the truth table before. The circuit has 8 different outputs depending on their condition. For example:

To achieve output N, the input condition needs to be set as:

- Amplifier 5 fails
- Both spare channels are available

Once the condition has been fulfilled, output N will be activated.

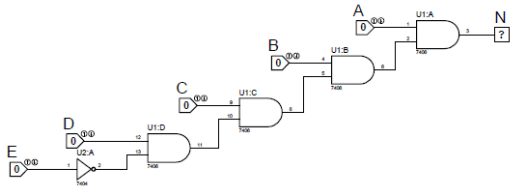

Figure 4: Logic circuit for output N

3.2 Relay circuit

The relay circuit for N+2 is constructed to show how the internal switches works. One circuit contains an amplifier connected to speaker bus and two relays connected to both spare channels.

Table 2: Digital output condition

Digital Output						
X4	X3	X2	X1	X0	Condition	R1
0	0	0	0	0	All funtional	0
0	0	0	0	1	AMP1 down, SP1 used	1

Based on the table above, when amplifier 1 is faulty, and spare channel 1 is used, the digital output signal that will be sent to trigger the relay is 0 0 0 0 1. As long as the scenario is to trigger just amp 1 for any spare channel, the digital output would be 0 0 0 0 1. This applies for other conditions, where specified output will be used to trigger their inputs.

For instance, below figure shows that relay 1 is linked to speaker bus 1 and spare channel 1, while relay 2 is linked to the same speaker bus and spare channel 2. Similarly, relays3 and 4 are linked to speaker bus 2 and the spare channels. The circuit used a single pole, double throw switching component. Considering each of the amplifier are always connected to both spare channels, the type of relay switch used will influence the output.

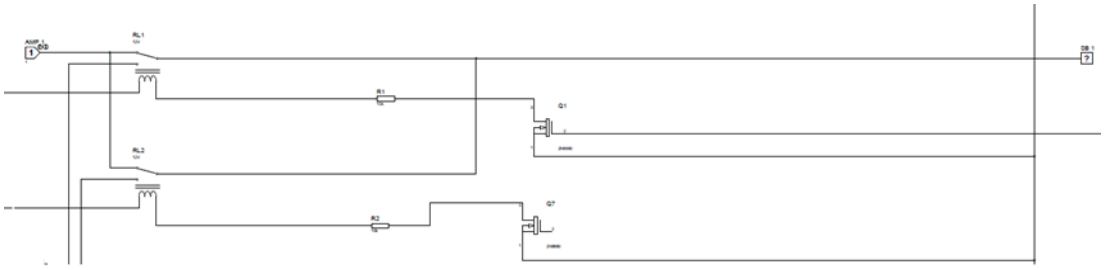

Figure 5: Relay 1 connected to speaker bus

4. Conclusion

To conclude the project, the basic principle/concept of the N+2 system for amplifier is fully understood. Therefore, based on this understanding, a complete logic circuit is designed with N+2 system for amplifier. Moreover, a simulation of how the system functions is completed using Proteus software to construct its logic and relay circuits. The circuits are based on the Boolean expression done.

Finally, from the simulation, it shows that the system managed to give output based on the simulated failure from amplifier.

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