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Implementation of Public Address System Using Anchor Technology

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Abstract

A public address (PA) system installed in a building is a system that delivers alerts, announcements, instructions, etc. in an emergency or disaster situation. As for the products used in PA systems, with the development of information and communication technology, PA products with various functions have been introduced to the market. PA systems recently launched in the market may be connected through a single network to enable efficient management and operation, or use voice recognition technology to deliver quick information in case of an emergency. In addition, a system capable of locating a user inside a building using a location-based service and guiding or responding to a safe area in the event of an emergency is being launched on the market. However, the new PA systems currently on the market add some functions to the existing PA system configuration to make system operation more convenient, but they do not change the complex PA system configuration to reduce facility costs, maintenance, and management costs. In this paper, we propose a novel PA system configuration for buildings using audio networks and control hierarchy over peer-to-peer (Anchor) technology based on audio over IP (AoIP), which simplifies the complex PA system configuration and enables convenient operation and management. As a result of the study, through the emergency signal processing algorithm, fire broadcasting was made possible according to the detection of the existence of a fire signal in the Anchor system. In addition, the control device of the PA system was replaced with software to reduce the equipment installation cost, and the PA system configuration was simplified. In the future, it is expected that the PA system using Anchor technology will become the standard for PA facilities.

Keywords: *Audio over IP, Anchor, OAC, Public address system,*

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1. Introduction

Audio systems used in industry are divided into public address (PA) systems and sound reinforcement (SR) systems [1]. PA system is a broadcasting system used in large-scale public or commercial facilities, and is a system for delivering various information, guidance, and warnings [2, 3]. PA system consists of input devices (radio tuner, CD player, microphone), emergency devices (fire receiver, fire source transmitter), control devices (audio mixer, control device), output devices (amplifier, speaker system), and audio sources and listeners can be in different spaces [4-6]. SR system consists of input devices (radio tuner, CD player, microphone), control devices (audio mixer, control device), output devices (amplifier, speaker system), and the audio source and listener can be in the same room [7]. The PA system installed in the building can be distinguished from the SR system by being able to broadcast fire-related in conjunction with the fire alarm device. The PA system consists of a very complex system that connects and uses devices with different functions [8]. This paper aims to simplify the existing complex system configuration by replacing the emergency device and control device of the PA system with software using audio over IP (AoIP)-based Anchor technology to make a novel PA system configurable. Section 2 describes the traditional PA system configuration and AoIP-based Anchor technology were analyzed, and Section 3 describes the novel PA system configuration through Anchor technology was described. Section 4 presents the experimental results. Section 5 discusses the conclusions and future development plan of Anchor technology-based PA system.

2. Audio System Configuration

2. 1 Public Address System Configuration

PA system facilities should quickly disseminate emergency disaster situations such as earthquakes and fires to people in the building so that they can initiate efficient evacuation actions [9]. The building's PA system facilities must be installed to comply with the Fire Services Act.

- The audio input of the loudspeaker must be 3 W (1 W for indoor installation) or more.
- Loudspeakers shall be installed on each floor, but the horizontal distance from each part of the floor to one loudspeaker shall be less than the distance that can effectively issue an alarm in each part of the floor.
- When installing a volume controller, the wiring of the volume controller shall be three-wire.
- Install the control switches on the control panel at a height of at least 0.8 m and no more than 1.5 m above the floor.
- For a specific firefighting object having 11 floors (or 16 floors in the case of an apartment building) or higher, an alarm can be issued by changing the alarm floor according to the ignition floor.
- To be shared with other broadcasting equipment, it shall be structured to block broadcasts other than emergency alarms in case of fire.
- Induction failure should not be caused by other electric circuits.
- When two or more operation units are installed in one specific firefighting object, install facilities that enable simultaneous communication between the places where each operation unit is located, and broadcast to all areas of the specific firefighting object from any operation unit.
- The time required from receiving the fire signal according to the triggering device to the automatic start of effective broadcasting for the fire situation and evacuation at the required volume promptly shall be less than 10 seconds.

- The sound device shall be capable of producing sound at 80% of the rated voltage and operating in conjunction with the operation of the automatic fire detection system.

In general, PA system installations should consider the above factors [10]. The composition of the PA system varies depending on the purpose of use and the size of the building, and the PA system is configured in accordance with the Fire Services Act. In PA system, the power amplifier is determined by the quantity and capacity of the speakers [4]. The control device is determined by the size of the PA system and the purpose of operation. The audio sources used in the PA system include radio tuner, CD player, chime & siren, and microphone. The PA system's emergency device works in conjunction with the fire alarm control panel to provide quick evacuation instructions and alerts through the PA system in the event of a fire [2]. Figure 1 shows a diagram of the PA speaker cable conduit line system of the building. The capacity and number of speakers are placed in consideration of the height of the floor and the noise level, and the speaker lines are separated and wired according to the use of the room in the building [9, 11]. Speaker line separation is also related to the capacity of the power amplifier.

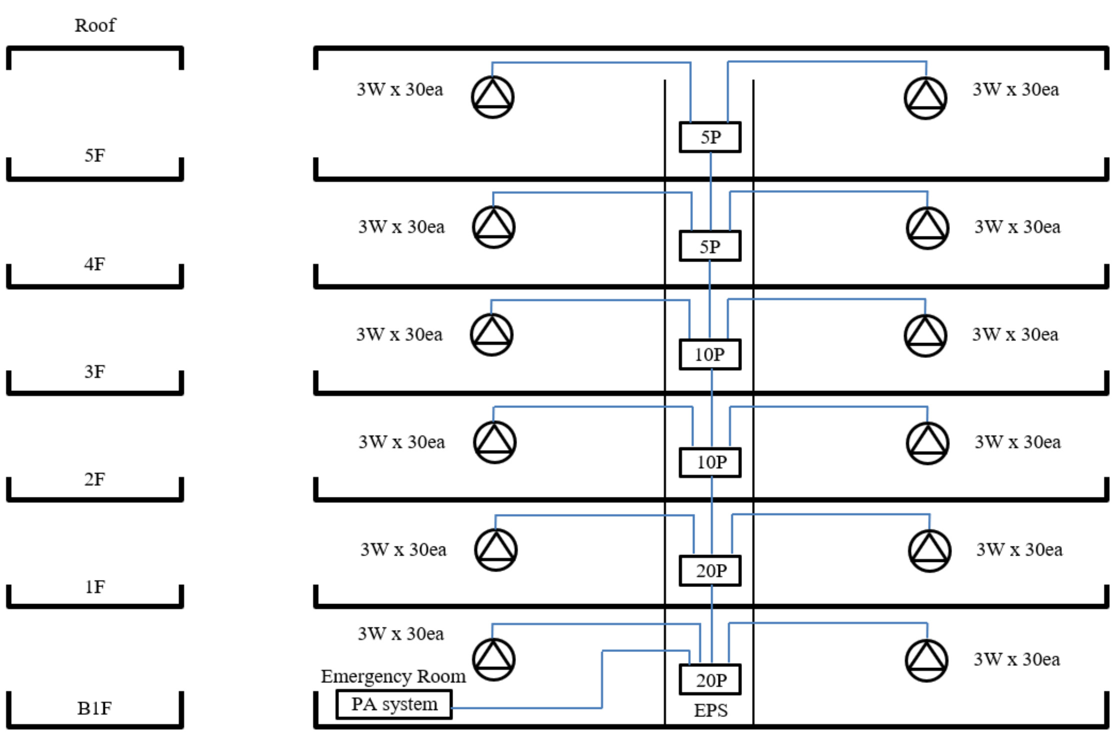


Figure 1. PA system speaker cable conduit line block diagram

For example, if the power amplifier can output 120 W, 40 speakers of 3 W can be connected in parallel and used [4, 11]. Speakers on each floor are wired with heat-resistant wires to the place where the power amplifier is located through the speaker terminal box in the electric pipe shaft (EPS) room. Since the PA system needs to receive the fire signal of each floor from the disaster prevention center, it is installed in the disaster prevention center or a place close to the disaster prevention center. Figure 2 shows a schematic diagram of the PA system based on Figure 1. When broadcasting by selecting an audio source (microphone, radio tuner, CD player, chime & siren) in the PA system, the audio source can be transmitted by manipulating the speaker selector of the floor to broadcast.

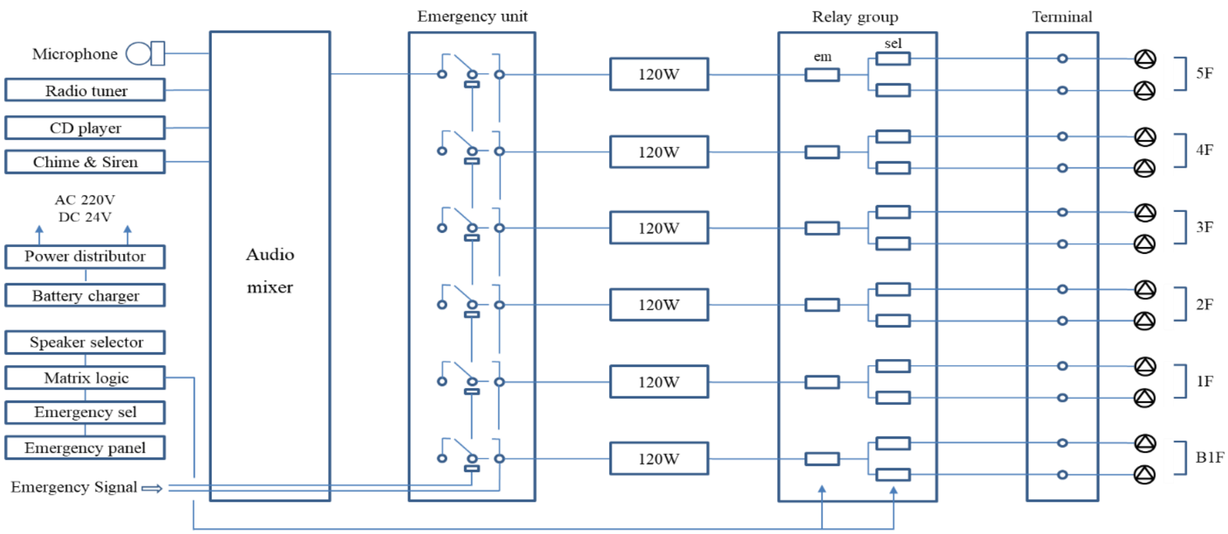


Figure 2. PA system configuration

If there is a fire in the building, the fire alarm control panel in the emergency room receives a signal from the floor where the fire occurred. When a fire signal received, the emergency unit blocks the general broadcasting signal by operating the relay on the fire occurred floor and the upper floor. And emergency sel operates the em of the relay group to make evacuation broadcasts in accordance with the fire on the floor concerned and the upper floor [12]. As above, the facilities of the conventional PA system require various types of equipment, and each cable is complicatedly connected. In addition, maintenance and cost aspects must be considered in order to configure the PA system [13]. In order to maintain the PA system, the relevant expert must visit the site and regularly inspect the equipment, and if there is a problem with the equipment, there is a time problem and a cost to find the cause of the problem.

2. 2 Anchor Technology

Industrial audio systems constitute each system according to the purpose of use and size. The equipment of the audio system transmits and receives signals through the audio cable, and operates the audio system through the audio mixer [14]. However, the configuration of the audio system using the audio cable has a problem in that noise may be generated due to a potential difference according to different installation environments [15]. Moreover, when transmitting over long distances, line loss and the resulting signal level can be attenuated. In order to solve the above problems, audio signals are transmitted and received using AoIP technology, which is a network-based audio signal transmission technology. AoIP is a technology that transmits audio signals over a network, and it is possible to transmit and receive high-quality audio data over a long distance. In addition, since audio signals are transmitted and received using a LAN cable, an audio system configuration can be constructed at a lower cost than conventional audio cables [16-18]. Table 1 compares the characteristics of AoIP technology leading the audio system market. CobraNet is a technology that transmits up to 64 channels of audio signals in real time over OSI layer 2 [19, 20]. Cobranet can only be used on an intranet, and it uses bundles, which are proprietary packages, to synchronize and communicate with the network.

Table 1. Comparison of audio network protocol

Technology	Year	Control Communications	Latency	Transport	Transmission Scheme	Mixing	Network Capacity	Sampling Rate
CobraNet	1996	Ethernet, SNMP, MIDI	1 1⁄3, 2 2⁄3 and 5 1⁄3 ms	Ethernet data link layer	Isochronous	Network = No Independence = No	More than 32	96 kHz
Dante	2006	IP, Bonjour	84 μs or greater[h]	Any IP medium	Isochronous	Network = Yes Independence = No	More than 32	48 kHz
AVB	2011	IEEE 1722.1	2 ms	Enhanced Ethernet	Isochronous	Network = Yes Independence = No	More than 32	192 kHz
Arria Live	2013	Ethernet	2.3 ms	Ethernet	Isochronous	Network = No Independence = Yes	32 CH (mono)	48 kHz
Anchor	2017	IP, UDP	10.7 ms	Ethernet (DIX Ethernet)	asynchronous	Network = Yes Independence = Yes	16 CH (stereo)	48 kHz

Dante technology transmits uncompressed multichannel audio signals over IP. In particular, it can transmit audio signals at 24-bit, 48 kHz at 100 Mbps [16, 21]. AVB technology is a technology that can simultaneously transmit audio/video signal transmission and control signals, and is applied to industrial audio systems and PA systems [20-22]. It is a technology that compresses audio/video signals and transmits and receives data in real time, and has been internationally standardized by the Institute of Electrical and Electronics Engineers (IEEE) [23-25]. Arria Live transmits and receives audio data through OSI layer 2, and audio mixing is possible independently on the receiving side. Arria Live has up to 32 mono input channels and 16 output channels. Arria Live can also be used in a variety of ways in SR systems, including live performances and recording studios. However, since system configuration is only possible on the intranet, Arria Live's own technology does not allow for broadband system configuration [16, 26]. Anchor is an AoIP-based audio signal transmission technology released in 2017 that uses IP to transmit and receive audio signals uncompressed. Anchor can be transmitted to 16 stereo channels, and can be received without limit. Anchor system configures the system by connecting the audio source and output device to the on-site audio center (OAC), a device that transmits and receives IP. The OAC consists of a transmitting OAC and a receiving OAC, and the control of audio signal data is performed by the receiving OAC independently selecting the incoming data from the transmitting OAC to mix the signal or control the audio level. In addition, Anchor has audio mixer, graphical EQ, and time delay functions, enabling a novel audio system configuration different from the conventional audio mixer-centered audio system configuration [16, 27, 28]. Anchor technology consists of an OAC that transmits and receives audio signals and a network-based on audio/video integrated control system (NAVICS) that can control it [29, 30]. Anchor's NAVICS presents a novel paradigm for the audio industry as it can control Anchor without restrictions on computing environments such as Windows, Linux, Android and IOS. Figure 3 shows the SR system configuration based on the Anchor technology. Anchor technology can mix and control audio signals without an audio mixer by exchanging audio signal data between input equipment and output equipment (power amplifier, speaker system) through the HUB and transmitting and receiving OAC signals.

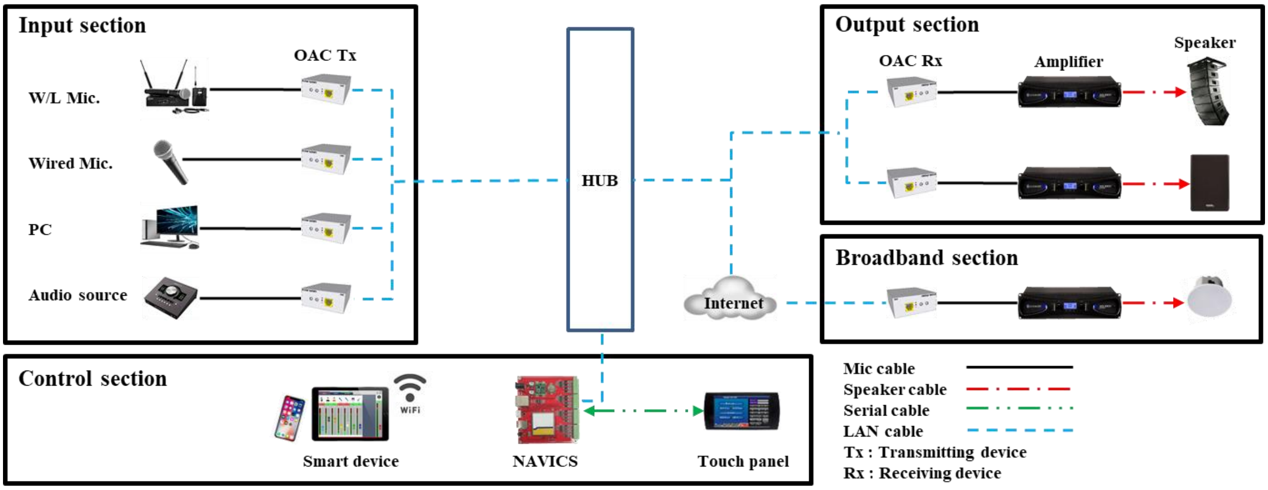
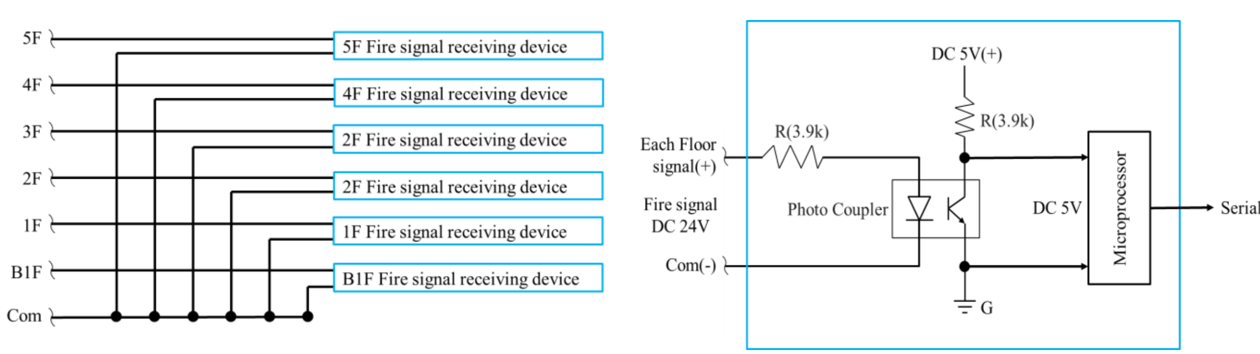


Figure 3. SR system configuration based on Anchor

In addition, it is possible to configure audio system configuration limited to local to wideband through network. Audio control of the SR system can be controlled by the operator by connecting to NAVICS over the network from any location. However, the audio system configuration using the anchor technology was currently applied only to the SR system, and it was impossible to use it for the PA system. Section 3 describes the composition of a novel PA system using Anchor technology.

3. Public Address System Configuration based on Anchor

PA system configuration using Anchor technology is possible to implement PA system through Anchor system through reception of fire signal coming from fire alarm control panel in emergency room and processing of received data. Figure 4 shows the process of receiving and processing fire signals from the PA system. Figure 4(a) shows the fire signal line of each floor coming from the fire alarm control panel in the emergency room to the fire signal receiving device of the PA system. The fire signal line on each floor sends DC 24 V when a fire occurs. Figure 4(b) shows a picture showing the process of detecting and processing the presence of a fire signal by receiving the fire signal line coming from the fire alarm control panel.



(a) Fire signal wire connection diagram **(b) Fire signal receiving device**

Figure 4. Fire signal reception data processing

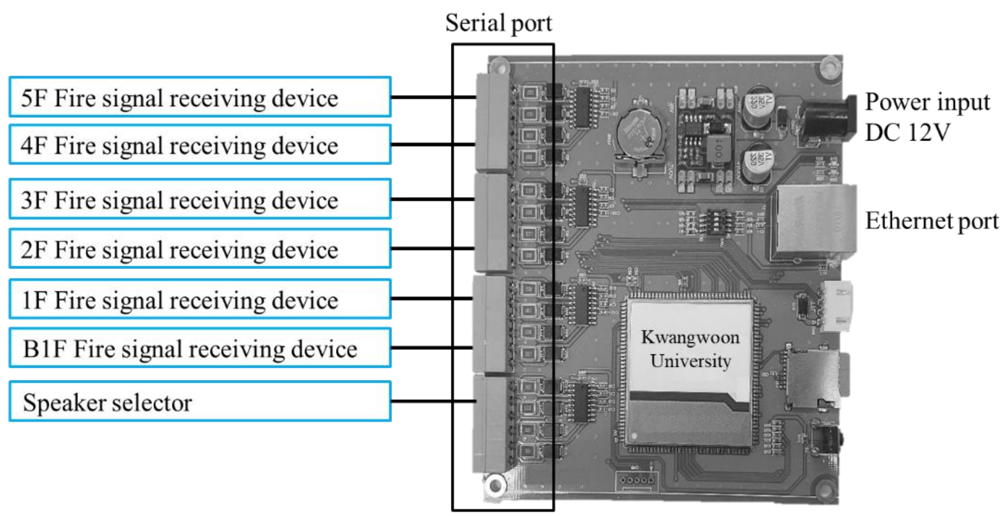


Figure 5. Wiring diagram connecting the fire signal receiving device to NAVICS

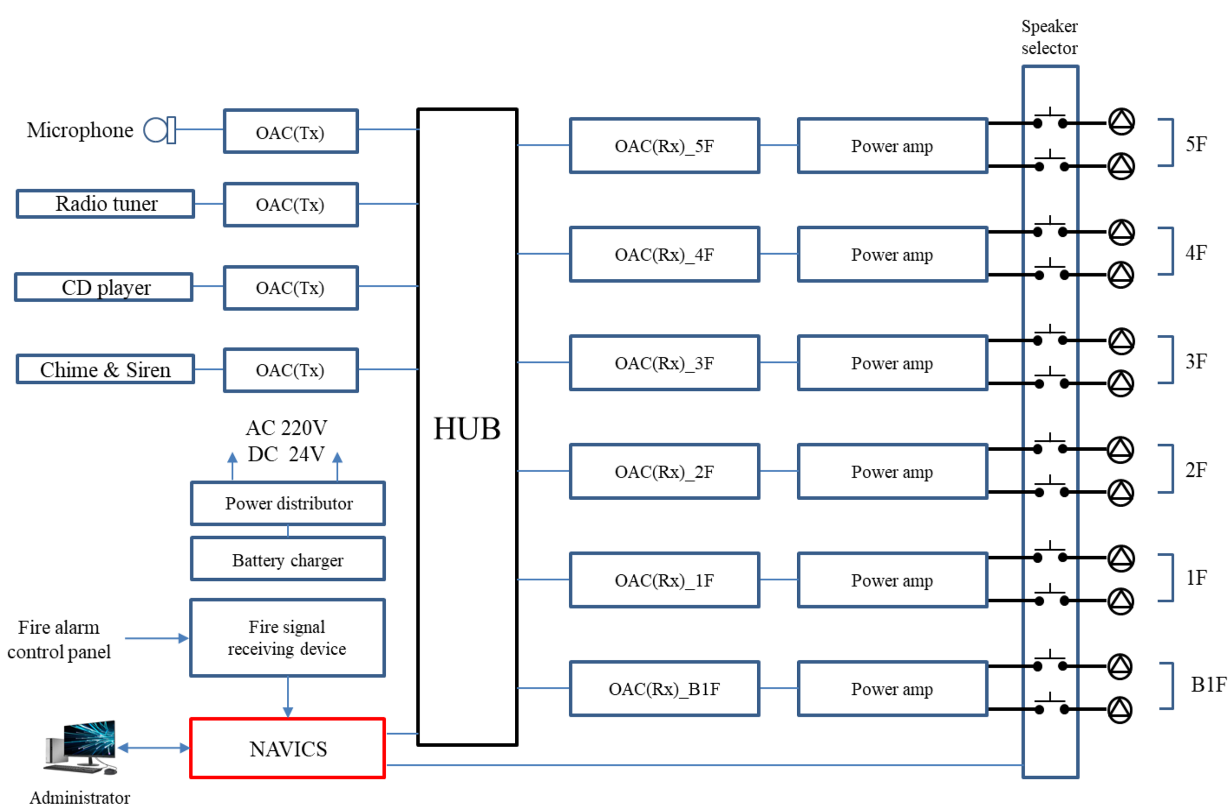


Figure 6. PA system diagram based on Anchor technology

Figure 5 shows the wiring diagram connecting the fire signal receiving device to NAVICS. Anchor technology consists of OAC that transmits and receives audio signals and NAVICS that controls OAC. Each

NAVICS has 1 Ethernet port and 8 Serial ports, and these ports can communicate with external devices. The Ethernet port of NAVICS can be connected to the HUB to control the transmitting and receiving OAC or to communicate with the control equipment of the PA system.Serial data of the fire signal receiving device receives fire information through the Serial port of NAVICS. In a small-scale PA system, it is possible to operate with one NAVICS, but in a large-scale PA system, there may be many devices that need to be connected to NAVICS. If the number of devices to be connected is greater than the number of ports provided per NAVICS, it is possible to expand according to the system size by connecting additional NAVICS. Figure 6 shows PA system configuration using Anchor technology. Input device (microphone, radio tuner, CD player, chime & siren), output device (power amplifier, speaker system) and power supply device are the same as the existing PA system. Anchor-based PA system configuration enabled the conventional control device with OAC, and all matters for the PA system were implemented through this study. Data detected through the fire signal receiving device is sent to NAVICS. NAVICS analyzes the signal received from the fire signal receiving device and operates the PA system for fire evacuation.

4. Implementation of Fire Signal Receiving Device Using NAVICS

In the Anchor-based PA system implementation, the fire signal receiving device receives the fire signal of each floor coming from the Fire Alarm Control Panel, converts the received data into Serial data, and sends it to Anchor's NAVICS to implement the PA system. Algorithm 1 represents the algorithm for processing the emergency signal received by the microprocessor of the fire signal receiving device in pseudo code. Microprocessor expresses Hi(1) if there is an emergency signal and receives Low(0) if there is no emergency signal. Lines 6 to 7 of algorithm 1 record the current time in Time_flag as a conditional statement for counting when Em_signal Hi(1) is received.

Algorithm 1 Algorithm for processing the emergency signal received by the microprocessor of the fire signal receiving device

```
1:   Time flag = 0
2:
3:   While True:
4:           Em_signal = Fire signal reception data
5:
6:      If Em_signal = 1 and Time flag = 1
7:           Time flag = Now time
8:
9:      else if Em_signal =1 and (Now_time - Time_flag == 10 Sec)
10:          Serial_Tx (“Fire_signal_on”)
11:          Time_flag = 0
12:
13:     else if Em_signal =1 (Now_time - Time_flag > 10 Sec)
14:          Time_flag = 0
15:
16:     else if Em_signal = 0 and (Now_time - Time_flag > 10 Sec)
17:          Time_flag = 1
18:          Serial_Tx (“Fire_signal_off”)
19:
20:     else if Em_signal = 0 (Now_time - Time_flag < 10 Sec)
21:          Time_flag =1
25:
26:          loop delay time (1 sec)
```

Lines 9 to 11 receive the received Em_signal Hi(1), and if the received Em_signal Hi(1) is maintained for more than 10 seconds, Serial data (“Fire_signal_on”) is sent to NAVICS. Lines 13 to 14 are conditions for maintaining condition #2 when reception Em_signal Hi(1) is received and Em_signal Hi(1) is maintained for more than 10 seconds. Lines 16 to 17 receive incoming Em_signal Low(0), and send Serial data

("Fire_signal_off") to NAVICS when Em_signal Hi (1) is longer than 10 seconds. Lines 20 to 21 are the conditions for making the standby state for the first condition if Em_signal Low (0) is received and Em_signal Hi (1) is less than 10 seconds. Algorithm 2 represents the algorithm for processing the fire signal of each floor sent from the fire signal receiving device in NAVICS in pseudo code. Lines 1 to 8 of algorithm 2 are stipulated for use in programs for transmitting and receiving Serial data. Lines 10 through 57 show the process of receiving and processing signals from the fire signal receiving device.

Algorithm 2 Algorithm for fire signal processing of each floor in NAVICS

```
1:        B1F_receive = serial.Serial(port=‘COM0', baudrate=9600, bytesize=8, parity='N', stopbits=1, timeout=0.1)
2:        1F_receive = serial.Serial(port=‘COM1', baudrate=9600, bytesize=8, parity='N', stopbits=1, timeout=0.1)
3:        2F_receive = serial.Serial(port=‘COM2', baudrate=9600, bytesize=8, parity='N', stopbits=1, timeout=0.1)
4:        3F_receive = serial.Serial(port=‘COM3', baudrate=9600, bytesize=8, parity='N', stopbits=1, timeout=0.1)
5:        4F_receive = serial.Serial(port=‘COM4', baudrate=9600, bytesize=8, parity='N', stopbits=1, timeout=0.1)
6:        5F_receive = serial.Serial(port=‘COM5', baudrate=9600, bytesize=8, parity='N', stopbits=1, timeout=0.1)
7:        COM6 = serial.Serial(port=‘COM6', baudrate=9600, bytesize=8, parity='N', stopbits=1, timeout=0.1)
8:        COM7 = serial.Serial(port=‘COM7', baudrate= 115200, bytesize=8, parity='N', stopbits=1, timeout=0.1)
9:
10:     while True:
11:        If B1F_receive
12:              Speaker_selector_All_on()
13:              For OAC(RX) in (All count)
14:                    if B1F_receive and 1F
15:                       Mute off
16:                    else
17:                       Mute on
18:
19:        else If 1F_receiver
20:              Speaker_selector_All_on()
21:              For OAC(RX) in (All count)
22:                    if 1F_receive and 2F
23:                       Mute off
24:                    else
25:                       Mute on
26:
27:        else If 2F_receiver
28:              Speaker_selector_All_on()
29:              For OAC(RX) in (All count)
30:                    if 2F_receive and 3F
31:                       Mute off
32:                    else
33:                       Mute on
34:
35:        else If 3F_receiver
36:              Speaker_selector_All_on()
37:              For OAC(RX) in (All count)
38:                    if 3F_receive and 4F
39:                       Mute off
40:                    else
41:                       Mute on
42:
43:        else If 4F_receiver
44:              Speaker_selector_All_on()
45:              For OAC(RX) in (All count)
46:                    if 4F_receive and 5F
47:                       Mute off
48:                    else
49:                       Mute on
50:
51:        else If 5F_receiver
52:              Speaker_selector_All_on()
53:              For OAC(RX) in (All count)
54:                    if 5F_receive
55:                       Mute off
56:                    else
57:                       Mute on
```

Fire reception data can be processed up to the first basement floor and the fifth floor above the ground. In the case of the first basement floor, emergency broadcasting data processing for fire signals was made possible through conditional statements from lines 11 to 17. If a fire breaks out on the first basement floor, the speaker selector function is called to make the contact of the speaker selector All On, and it creates an environment for broadcasting to the floor where the fire occurs and the upper floor where the fire occurs. PA can be performed by controlling the OAC (Rx) that transmits audio signals from the power amplifier on each floor of the fire signal receiving device. When the emergency signal comes in, the relevant floor and the upper floor turn off the Mute of OAC (Rx), and the other floors turn on the Mute. As above, it was possible to implement a PA system using Anchor technology through the fire signal receiving device and emergency signal processing algorithm of NAVICS.

5. Conclusion

In this paper, we processed the emergency signal sent by the fire alarm control panel in the emergency room by the fire signal receiving device and NAVICS, and obtained the following results. First, the fire signal receiving device detects whether or not there is a fire signal sent from the fire alarm control panel, and converts it into Serial data so that it can be transmitted to NAVICS. NAVICS received the fire signal data of each floor sent by the fire signal receiving device and enabled fire broadcasting to the corresponding floor and upper floors. Second, it was possible to replace the control equipment with software using NAVICS with the PA system configuration based on Anchor technology. In addition, the existing complex cable connection could be simplified through transmission and reception OAC. Through this, it was possible to solve problems related to PA facilities and maintenance by simplifying the configuration of the PA system. In the future, we expect PA systems using Anchor technology to become industry standards.

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