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Bidirectional Alarm Equipment for Protection for Trackside Worker using Bone-anchored Speaker

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Abstract : Personnel maintaining or repairing the railway tracks or signaling facilities around tracks may experience the sensory disorder when doing maintenance works at the trackside of railway for long time. In this case personnel maintaining at the trackside may collide with the train since they cannot recognize the approach of motor-car although it approaches to the vicinity of maintenance workplace because of the sensory block phenomenon occurred due to their long hours of continued monotonous maintenance work. In order to prevent such motor-car accidents that may occur because railway track workers are unable to recognize the approaching train, the safety alarm equipment is developed to make the approaching motor-car send radio signals and bidirectional detection mechanism between approaching train and trackside personnel. It shows the possibility of utilization in various forms of safety equipment for workers only to the safety helmet to be worn by the maintenance workers while using the configuration of transmitting/receiving sides. In the paper it is represented new alarm equipment, which is the bone-anchored speaker-based safety helmet to be worn by the maintenance workers.

Key words: bidirectional alarm equipment, bone-anchored speaker, RF-based equipment

1. Introduction

Workers maintaining the railway tracks or signaling facility around tracks may experience the sensory disorder when they do routine works for many hours and they may not recognize the approaching motor-car, leading to train accidents. In addition, even in the motor-car base, workers may not recognize the motor-car running at a slow speed or take notice of the approaching motor-car when they are absorbed in working. Since the motor-car driver is not able to accurately locate the points where maintenance works are done, accidents can occur at any times. In other words, workers are exposed to the accident risks when they are performing checks or maintenance works at or around tracks and/or motor-car bases, because they are sometimes unable to recognize the approaching motor-car [1].

In this study, the safety alarm equipment is proposed to reduce the casualty accidents that may occur because railway track workers experience the sensory disorder and do not recognize the approaching motor-car. In order to prevent such motor-car accidents that may occur because railway track workers are unable to recognize the approaching motor-car, the safety alarm equipment is developed to make the approaching motor-car send radio signal [2-4]. Then, a receiving set receives the radio signals and warns workers of the approaching motor-car. In this study, we developed that RF signal receiver using bone-anchored speaker-based safety helmet which is carrying by trackside workers. In this paper this developed receiver will be called as safety alarm equipment. The on-board safety alarm equipment have been represented the author's previous paper [4].

The developed alarm equipment held by the maintenance personnel sends signals telling the location of personnel to motor-car, allowing motor-car driver to know exactly where maintenance personnel work. Such interactive wireless communication links may contribute to reduction of train accidents. Figure 1 is the one showing a configuration of safety alarm equipment to secure the safety through bidirectional detection between the motor-car and trackside worker's safety helmet proposed in this paper, and it is the safety equipment making workers evacuate by providing various forms of alarm sounds through recognition of the approaching motor-car by worker's safety equipment if the motor-car approaches within the some distance of front,

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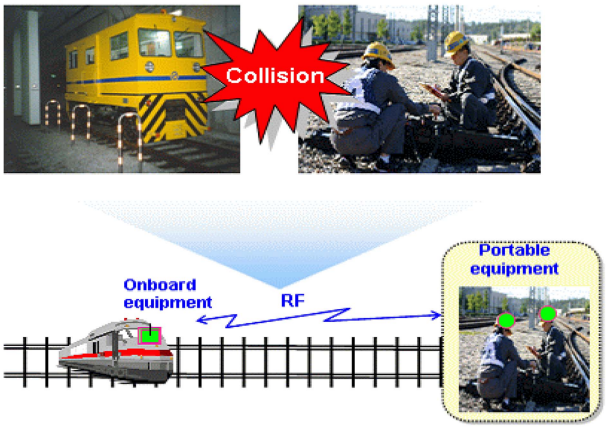

Fig. 1. Configuration of proposed safety equipment.

and on the contrary, inducing to drive carefully by making it possible to check even in the motor-car also if there is any worker existed in the front or not. This is to induce careful driving by providing a motor-car driver with the information also so that the driver can check if there is any work conducted by worker within the fixed distance of front or not [5]-[7].

2. Concept of Bone-anchored Speaker-based Safety Alarm Equipment

The bone-anchored speaker is the speaker making sounds conducted through the vibration of skull, and it is the technology making sounds conducted through this vibration of transducer by contacting bone conduction transducer at the part around ears [5-7]. Since this bone conduction speaker is to be attached around the ears like Figure 2, there is no interference with hearing other sounds at all because the headset does not cover the ears, and in addition, there is no unreasonable auditory sense at all even if wearing it for a long time, and it is possible to recognize the alarm sound informing the train approaching at any noisy environment.

This study proposed and designed the bone-anchored speaker-based safety helmet which connects the receiver and bone-anchored speaker-based with existing general

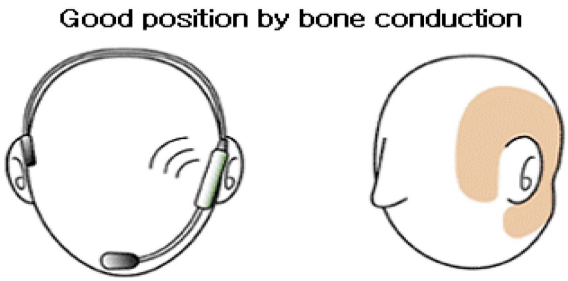

Fig. 2. Wearing location of the bone-anchored safety helmet.

safety helmet. To raise the performance of bone conduction, the bone conduction transducer must be attached around ears like Figure 2. Therefore, we made the bone conduction transducer attached at this part, and in addition, we designed and constructed the appearance of bone conduction transducer so that it can be attached regardless of the form of various safety helmets. And we made the wireless transmitter-receiver and this bone conduction transducer interfaced each other so that it can receive the information on train approaching being transmitted from the train.

3. Development of New Alarm Equipment

All personnel and motor-car equipped with the safety equipment proposed in this study may perform real-time communication. When the equipment detects the presence of motor-car or personnel within the pre-setting area, it generates alarm sounds, vibration, or LED signals to help personnel recognize the presence of personnel or motor-car. The prototype of the safety equipment was manufactured for subway motor-car in order to perform the functional testing and verification. The safety equipment at motor-car will perform real-time communication with all personnel carrying the device. The on-board safety alarm equipment have been represented the author's previous paper [4], but the safety alarm equipment for trackside personnel has developed newly using bone-anchored speak-based safety helmet in this paper.

When the equipment detects the presence of motor-car or personnel within the pre-determined area, it generates alarm sounds, vibration, or LED signals to help personnel recognize the presence of personnel or trains. Portable equipment carried by maintenance personnel and the safety equipment at motor-car will perform interactive communication. The equipment at motor-car is set at transmission mode and the one held by maintenance personnel is set at reception mode. In other words, when the personal equipment receives the radio signals sent from the one at motor-car together with ID, it sends the response signals and ID to allow motor-car operators to recognize the presence of maintenance personnel. The proposed safety equipment was manufactured and successfully tested at Seoul Metro lines, demonstrating its feasibility.

If the proposed safety equipment is applied to actual railway environments, the safety equipment carried by personnel will interactively communicate with the one at motor-car to make personnel recognize the approaching motor-car. In addition, motor-car drivers also locate the position of track workers. In this way, casualty accidents will be considerably reduced.

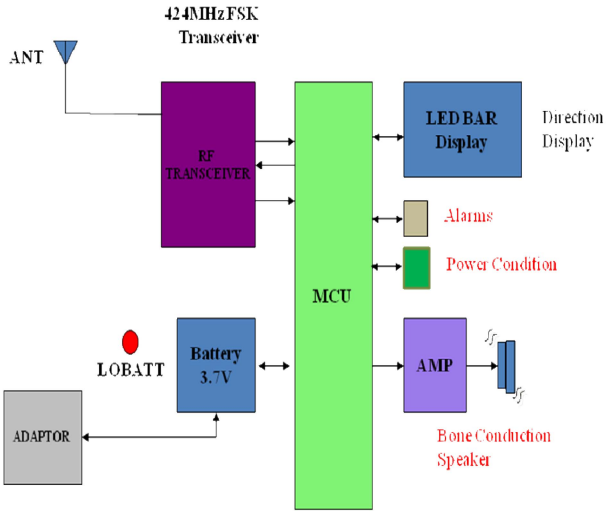

Fig. 3. Configuration of the ob-board terminal.

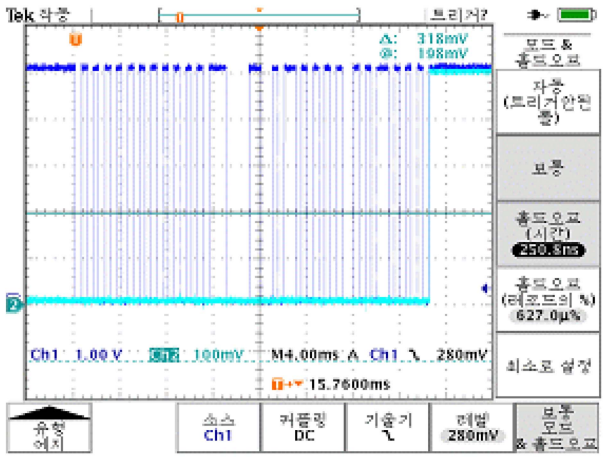

Fig. 4. Output signals at RF sender on on-board equipment.

Figure 3 is the one showing the configuration of on-board terminal of safe alarm equipment like previous research [4], and it is consisted of RF module to send and receive RF signals periodically, MCU module handling the occurrence of periodic RF signal and operation mechanism of alarm signal, LED module for the output of alarm signal by the light, LCD module to display the information, AMP and bone conduction speaker parts for the output of alarm signal by the sound, and the power supply module for the input of power supply from a motor-car. Power supply module was made to be input from 5V to 40V so that the power supply of various motor-cars can be input. The frequency band of wireless signal used in this prototype was 424 MHz which is the ISM band. The alarm signal by LED was made to be displayed in different color respectively in accordance with that whether there is any worker existed in the front or another motor-car existed in the front. The alarm sound was made to be adjusted by the motor-car driver, and the LCD panel was made so that the unique number of approached worker's terminal or terminal of another motor-car can be displayed. If wireless signals are being fed back by various terminals within an approaching section, the ID number of terminal was made to be expressed successively in the order of wireless signal feedback. The output of wireless signal of the motor-car terminal of motor-car and that for worker is in the ISM band, and it was adjusted within 10 mW so that the radio wave range can be about 250~300 m to suit for the metropolitan rapid transit [4].

The transmitting & receiving modules were constructed in the same form for the on-board and for worker as well like the form shown, and the speaker using the bone conduction transducer constructed through this task is same signal as that in Fig. 4.

Especially, it is the safety equipment which makes workers evacuate safely by informing them of the alarm to approaching motor-car through bone conduction speaker attached at the safety helmet of trackside maintenance worker not in the general method of alarm expression. Of course, it is identical to the basic operation of safety equipment mentioned in the previous section in that this is the safety equipment to reduce casualties in accordance with the bidirectional RF link by which even the driver of motor-car can check the location of worker by transmitting the location of worker from the safety helmet of maintenance worker to the motor-car. Bone conduction speaker attached at the safety helmet in this section has the characteristics to hear sounds through vibration of the skull, and it was not difficult to prove its utilization because the bone conduction speaker using this principle was commercialized already.

Bone conduction speaker refers to the hearing through vibration of the skull, and the bone conduction speaker using this principle is commercialized. Since this bone conduction speaker is attached around the ears, there is no hindrance at all to hear other sounds because the headset does not cover the ears, and it is never unnatural for hearing even when wearing it for a long time, and it is possible to recognize alarm signals to alert an approach of motor-car in any noisy environment.

Since this bone conduction can have the function of speaker only if it is attached around the ears, there is no hindrance at all to hear other sounds even when the headset does not cover the ears. In addition, it is never unnatural for hearing even when wearing it for a long time, and it shows a big advantage that it is possible to recognize alarm sounds to alert an approach of motor-car in any noisy environment.

Therefore, we implemented a bone conduction safety helmet which connects the receiver with bone conduction speaker by using an existing general safety helmet. As explained previously, the function and operation mechanism of safety equipment is identical to that for safety equipment using the wireless proposed in the previous section, and it has the only difference that its method of expressing information on the approach of motor-car is the safety helmet using a bone conduction speaker. The prototype of manufactured safety helmet is divided into the equipment for vehicle and for worker which is identical to the safety equipment proposed in the previous section, and the speaker using a bone conduction vibrator is identical to Fig. 5 Since this bone conduction speaker was attached to the chinning string of safety helmet after being fastened and receives alarm sounds through bone conduction speaker, the worker can recognize hazardous factors immediately and evacuate because he/she can hear the ambient sounds and signal sounds transmitted from the motor-car at the same time since the ears of worker were not covered. All of the workers wearing safety helmets with manufactured bone conduction method and vehicles will communicate on a real-time basis, and the worker can check and grasp alarm sounds immediately through bone conduction and operation of LED if there is any motor-car or person existed when a motor-car approaches within the fixed distance.

The equipment for vehicle sends signals continuously while tracking the location of worker, and the receiver attached at the safety helmet of worker senses them and outputs alarm sounds and alarm signals in LED to the equipment for motor-car simultaneously. Bone conduction receiver attached at the safety helmet receives wireless signals transmitted from the vehicle as a top priority and can recognize that the motor-car is coming by using three stages of wireless signals through bone conduction speaker

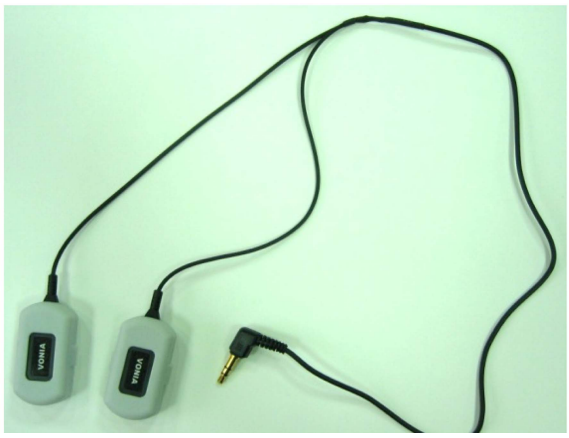

Fig. 5. Developed bone conduction vibrator speaker.

Fig. 6. Result of the prototype safety helmet for railways with bone conduction method.

at the safety helmet of worker while working. Band of wireless signal for developed prototype of the safety helmet with bone conduction speaker is 448.75 Mhz, and used 5 mW of output. Figure 6 is picture showing the result of final prototype of the proposed safety equipment which was manufactured in the form of safety helmet using the bone conduction speaker.

This bone conduction speaker is being secured and attached at the string for chinning of safety helmet. Since the alarm sound is being received through bone conduction speaker, the worker can recognize hazard factors and shunt immediately because he/she can hear the surrounding sound and the signal sound transmitted from the vehicle simultaneously owing to his/her uncovered ears. All of the workers attaching safety helmets in a constructed bone conduction manner and the vehicles will communicate on a real-time basis, and if entering into the fixed distance and if there is any vehicle or person existed, the worker can identify and grasp the alarm sound immediately through bone conduction and LED operation.

3. Conclusion

This paper explained the result of design and construction of the prototype safety equipment using the bone conduction transducer to reduce casualties of maintenance workers working at the railroad track-side. If this proposal is applied to the actual railroad site, it is expected that the occurrence of casualties colliding with the approaching train will be decreased sharply by making the worker enable to recognize the approach of train, and making the railroad vehicle driver also possible to recognize the worker at the front track-side in advance through this proposal installed at the railroad vehicle and two-way communications.

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