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적외선 시스템을 이용한 지상차상통신

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Trackside to Train Communication Using Infrared System

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요 약

열차에서 지상차상통신은 데이터를 전송하기 위해 트랜스폰더 또는 발리스 (balise) 와 같은 무선장비를 일반적으로 사용하고 있다. 그러나, 이러한 종래의 방식에는 다중경로 페이딩, 대역폭소스 제한, 다른 사용자들로부터의 간섭 등 과같은 단점들이 있다. 게다가 이러한 장비가 많이 설치될 경우에는 비용이 많이 든다. 이러한 문제를 해결하기 위하여 적외선 통신 시스템을 제안하고자 한다. 적외선 시스템을 사용하여 열차의 위치 같은 데이타를 열차로 전송 할 수 있다. 적외선 통신 프로토콜은 direct dedication configuration에 실용적인 무선 데이터 통신을 제공할 수 있다. 뿐만 아니라, pole configuration경우에 적외선 시스템은 풍부한 대역폭 그리고 경제적 장비설치비용, 폭우 때 장비이용의 신뢰성까지 제공한다. 본 논문에서는 통신기능과 실행평가측정 (measurement performance evaluation)에 대한 분석을 다루었다. 제안된 지상차상통신 시스템에는 적외선 수신기 및 적외선 송신기 사이를 약 6미터 까지 전송가능하며, 송신기의 반각은 19.65도로, 수신각은 15도로 설정되었다.

ABSTRACT

The conventional track to train communication is commonly using radio based equipment such as transponder or balise to transmit the data. However, there are some drawbacks of the conventional equipment, for example multipath fading, source of bandwidth limitation, and interference from other users. Moreover, the radio based equipment is very expensive when installed in large numbers. To address these problems, we propose infrared system for trackside to train communication system. Infrared system offers a transmission of data to train and it can be processed to obtain at least a train location. Infrared communication protocol provides practical wireless data communication for direct dedication configuration. Furthermore, on the pole configuration the infrared system provides an abundant bandwidth, an economically sensible, minimalized installation of equipment on the trackside and reliability for heavy rain environment. This paper concentrates on the communication function and measurement performance evaluation. The proposed trackside to train communication system covers about 6 meters between infrared receiver and infrared transmitter, whereas the half angle of the transmitter is set to 19.65° and the receiver angle is 15°.

키워드

Communication System, Infrared System, Trackside to Train Communication
통신 시스템, 적외선 시스템, 지상 차상 통신

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I. Introduction

For the monitoring and control of railway, the onboard system of the train must have information about the trackside of which the train will pass [1]. The vital items of information are at least position and speed of the train. The trackside equipment sends a data to train that will be used for controlling the train automatically. When the train passes a signal or a corresponding signal, the driver must not misread or ignore the signal and must not go too fast. Therefore, an effective trackside-to-train communication system is critically needed.

The conventional equipment is used to provide data communication from the track to the train includes mechanical devices, electrical contacts, electromagnetics, transponders and balise [2-8]. In recent years, the transponder and balise have commonly been used for trackside-to-train communication. In addition, radio frequency identification (RFID) is still under development to provide communication between trackside and train in the future [9]. The transponder and balise are based on radio system that has some advantages. The radio system provides not being bounded by the skyline [10] and offers ubiquitous coverage at moderate data rates [8],[13].

However, the radio system has some drawbacks, especially in a short range wireless communication system, such as multipath fading, source of bandwidth limitation [15], and interference from other users [11-13]. Moreover, the radio system is very expensive [14] when installed in large numbers. On the other hand, radio based equipment is commonly installed on tracksides where the performance will potentially be influenced by pooling water and poor track maintenance in a country with a humid climate.

In this works, we propose trackside-to-train communication using an infrared system for special environments such as slope areas. The infrared technology has been studied as a method of short range wireless communication. Infrared has several advantages compared with radio as a medium for short range communication. The main advantage is an abundance of unregulated bandwidth such as that over 200 THz in the 700-1500 nm range [13],[15]. Moreover, infrared radiation cannot pass through walls or other opaque barriers, so infrared is a secure medium [13], preventing casual eavesdropping [15]. In addition, the nearby users can use infrared links without interference. Finally, infrared links using intensity modulation and direct detection are not affected by multipath fading [11-13].

We design trackside-to-train communication using an infrared system to control the train on a sloped area. This proposed communication system provides an economic configuration, reduced installed equipment on the track, simplicity of maintenance, and compatibility with the environment.

II. Infrared System

2.1 Fundamental

Continually vibrating atoms are components that compose every object, with higher energy atoms vibrating more frequently. Electromagnetic waves will be generated by the vibration of all charged particles including these atoms. Furthermore, the radiation will be emitted continually by every object at a rate with a wavelength distribution based on the temperature of the object and its spectral emissivity, $\varepsilon(\lambda)$ [16].

Radiant emission is related to a blackbody that has the characteristic to absorb all incident radiation and, in contrast to Kirchhoff's law, is a perfect radiator. A blackbody radiates the maximum energy conceptually possible for a designated temperature. The Planck radiation law explains the radiative power and its wavelength distribution.

$$W(\lambda,T)=\frac{2\pi hc^2}{\lambda^5}\left[\exp\left(\frac{hc}{\lambda kT}\right)-1\right]^{-1} W/(cm^2\mu m) \tag{1}$$

$$P(\lambda,T)=\frac{2\pi c}{\lambda^4}\left[\exp\left(\frac{hc}{\lambda kT}\right)-1\right]^{-1} photons/scm^2\mu m) \tag{2}$$

where λ is the wavelength, T is the temperature, h is the Planck's constant, c is the velocity of light, and k is the Boltzmann's constant [16]. The increasing temperature causes an increase in the amount of energy radiated at any wavelength, but the wavelength of the peak emission decreases.

The electromagnetic spectrum of infrared radiation has a similar characteristic with visible light (VL) which is located between radio frequency (RF) and ultraviolet (UV) as shown in Figure 1 [17]. As invisible radiant energy, electromagnetic radiation has longer wavelengths than those of visible light, spanning from the nominal red edge of the visible spectrum at 700 nanometers (frequency 430 THz) to 1 mm (300 GHz).

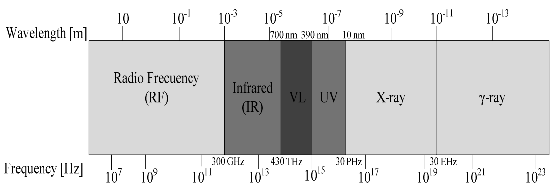


Fig. 1 Electromagnetic spectrum

In the transmission process through air, scattering and absorption reduce the radiation by changing the direction of a beam and suspended particles. While the scattering of larger particles is independent of wavelength, the smaller particles, which are on the same level as the wavelength of the radiation, show a λ-4 dependence that is recognized as Rayleigh scattering [16].

2.2 Wireless Infrared Communications

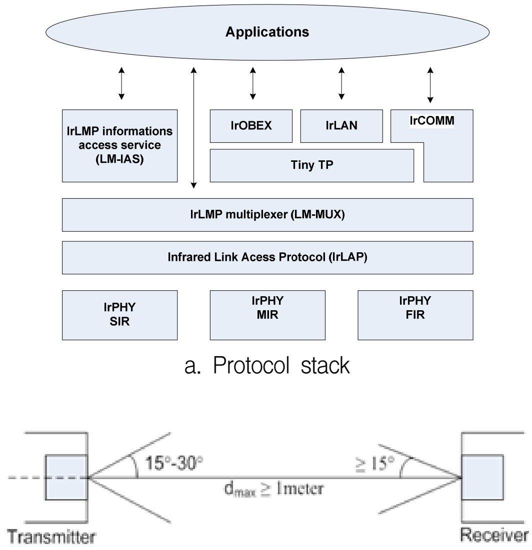
Wireless infrared communication has a number of advantages compared with radio in short-range wireless communication. An abundance of unregulated bandwidth is the main advantage. It allocates more than 200THz in a 700-1500 nm single range. In addition, the infrared beam cannot pass through walls and other opaque barriers, so it is a secure medium that pre-empts casual eavesdropping. Furthermore, interference is avoided when other infrared links are used independently. Moreover, infrared links have freedom from multipath fading when intensity modulation and direct detection are used [10-13].

Similar to other optical communication, infrared links can be designed into various configuration depends on the criteria of classification. Two practical criteria are used to classify the link design. According to the degree of directionality between the transmitter and receiver, the links can be divided into directed and non-directed. Directed links apply directional transmitters and receivers for building a link, whereas non-directed links apply transmitters and receivers with a wide angle, reducing the necessity for such pointing [11].

The other classification criterion is associated with the line-of-sight (LOS) and non-line-of-sight (NLOS) between transmitters and receivers. Due to efficiency and simplicity, almost all of the infrared configurations use a LOS path between the transmitter and receiver [11],[18].

2.3 Infrared Data Association (IrDA) Protocol

For interoperability of multivendor infrared link designs, a protocol is needed to communication each other. Compared with radio, the IrDA protocol provides low cost, small size, low power consumption, low error rate, very fast short range, and line of sight (LOS) links for wireless links. The IrDA 1.x protocol stack has three mandatory components, namely the IrDA physical layer (IrPHY), the IrDA link access protocol (IrLAP) data link layer, and the IrDA link management (IrLMP) layer as shown on figure 2a. The other protocols consist of two sub components such on an application channel multiplexer (LM-MUX) and a supported services database (information access services, LM-IAS) [19],[20].



a. Protocol stack

b. IrPHY interface specification

Fig. 2 The IrDA architecture and configuration

III. Material and Method

3.1 Set up

The transmission and reception of serial data over the infrared wireless medium are provided by the IrPHY layer as described on figure 2b. Frame construction and error detection functions are also provided by the physical layer, although they are often applied using a software component. The wavelength range of the operating light emitting diode (LED) for the infrared transmitter is 800-900 nm. In addition, the output intensities of the infrared transmitter are a maximum of 500 mW/Sr; however, the intensities are typically less than 100 mW/Sr. The angle range of the transmitter is 15o to 30o for a half angle field of view, whereas the receiver angle range is at least 15o [19],[20].

Serial infrared (SIR) physical layer uses a return-to-zero inverse for modulation with a 3/16 period duration and provides a data rate range of 9.6 - 115.2 kb/s [19],[20]. In this works, serial infrared type (SIR) was used to build communication system. The communication system comprises of transmitter and receiver with redundant configuration. The communication data protocol is provided by infrared data association (IrDA).

To evaluate the performance, the Bitscope logic analyzer and oscilloscope was applied to measure the optimum configuration in order to obtaining an effective communication system.

3.2 Operation

By installing on the pole, the infrared transmitter is energized power supply to transmit a beam with some configuration such as angle and distance to the receiver. By installing on the cabin, receiver obtains a beam from the transmitter to get a data that will be forwarded to onboard equipment.

The distance between the transmitter and the receiver is configured to reach an optimal distance to build communication system. The evaluation of setting distance is applied from the least distance of configuration to the peak distance.

3.3 Experimental Measurement & Calculation

The beam transmission from the transmitter to the receiver was measured with a distance from 70 cm to 600 cm using logic analyzer and oscilloscope (Bitscope). The transmitter angle was set to 19.65°

for a half angle field of view, whereas the receiver angle range is set as default to 15° [19],[20].

IV. Result & Discussion

The transmission and reception of serial data over the infrared wireless medium are provided by the IrPHY layer as described in figure 2b. The least distance between the transmitter and the receiver was set to 70 cm according to minimal configuration distance between trackside equipment and train cabin. In figure 3, it describes the distance range of configuration between the transmitter and the receiver in order to obtaining the performance of communication system.

In figure 4, the performance of beam transmission was described whereas orange signal is representative of transmitter signal, red signal is transmitter signal with modulated data identity and white signal is receiver output signal.

Figure 4a and 4b shows the performance of the beam transmission with distance between transmitter and receiver was set to 70 cm. The logic analyzer was set with various parameters such as focus time (FT), time base (TB) and sample rate (FS). The output signal is obtained at distance 70 cm.

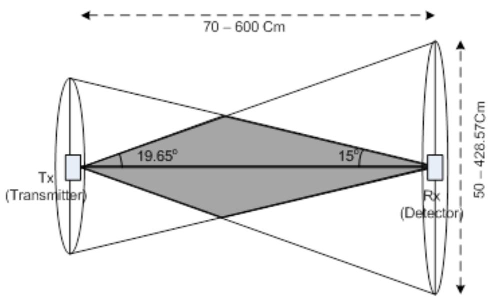
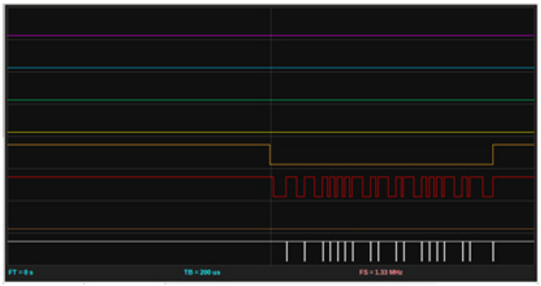
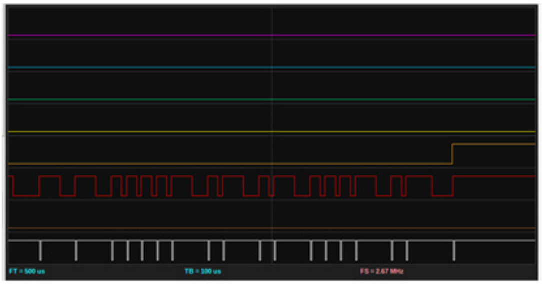


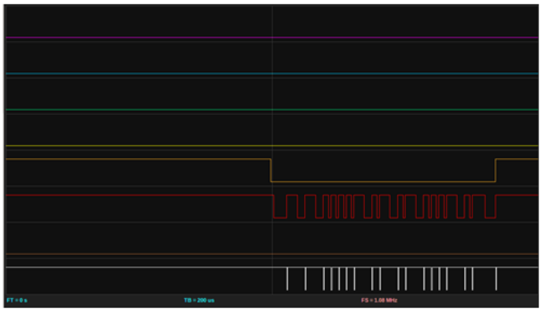
Fig. 3 Configuration of infrared system



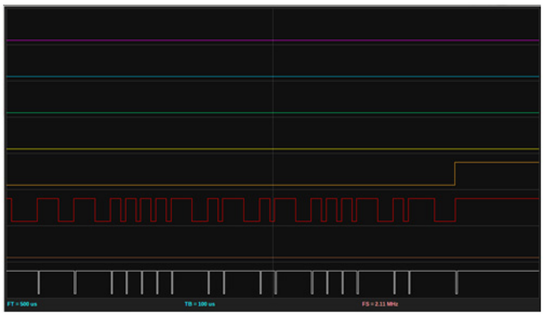
a. Distance 70 cm FT 0s TB 200us FS 1.33MHz



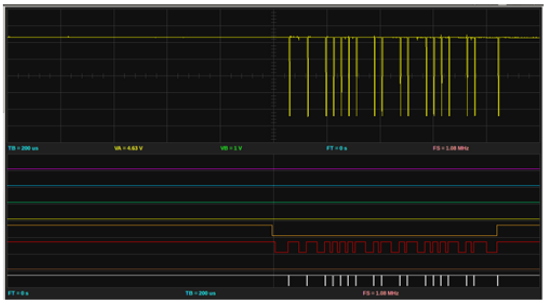
b. Distance 70 cm FT 500us TB 100us FS 2.67MHz



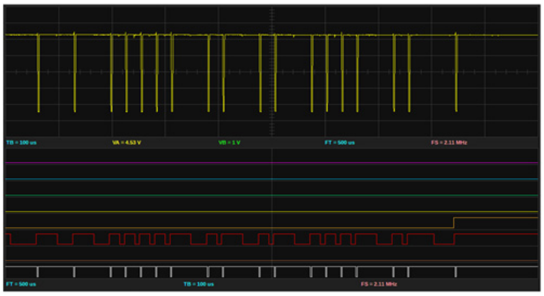
c. Distance 200 cm FT 0s TB 200us FS 1.08 MHz



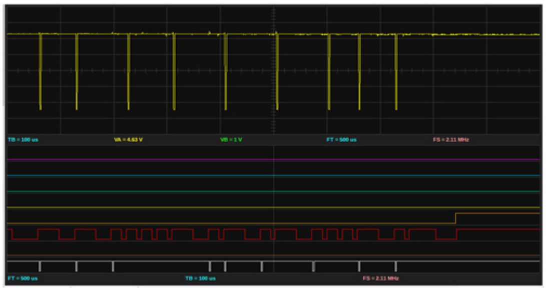
d. Distance 200 cm FT 500s TB 100us FS 2.11MHz



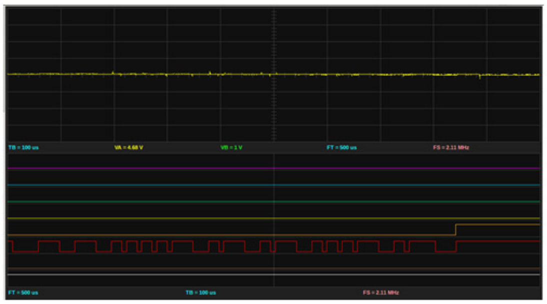
e. Distance 300 cm FT 0s TB 200us FS 1.08MHz



f. Distance 300 cm FT 500s TB 100us FS 2.11MHz



g. Distance 600 cm FT 500s TB 100us FS 2.11MHz



h. Distance 650 cm FT 500s TB 100us FS 2.11MHz

Fig. 4 Performance of transmission signal

In figure 4c and 4d, the distance configuration was set to 200 cm, whereas the output signal is good at the distance. The performance of output signal until 600 cm is still available to build communication that described in figure 4e, 4f, and 4g. The performance of the output signal is not detected when the distance between the transmitter and the receiver is more than 600 cm that displayed in figure 4h.

Moreover, in comparison with radio based communication, the infrared communication is not necessary to consider at least regulated bandwidth and interference.

V. Conclusion

In this works, the trackside to train communication using infrared system was proposed and the performance of the system was investigated. The beam angle of the transmitter is a 19.65o half angle and the receiver angle is a 15o half angle to obtain an effective received beam. Using line of sight configuration, the distance between transmitter and receiver is available to build communication system up to 600 cm by installing the transmitter on the pole and the receiver outside of the cabin. The system allows economical configuration, reduced installed device on the trackside, simple maintenance and compatible with the environment.

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