

Intelligent signalling system using train information

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Abstract

We have newly developed a device to transmit 40-bit digital information from trains to the ground at low costs. This equipment uses the ATS systems that has been introduced into all JR lines. Adding an information transmission function to ATS on-board equipment, we have verified through field examinations that high quality information transmission is possible without influencing the present function of ATS.

In this paper, we describe the concept of an intelligent signalling system using this equipment.

1 Introduction

On Sinkansen lines, the traffic is controlled by the Computer aided Traffic Control (COMTRAC) system, together with route control and passenger information by the train numbers transmitted from trains to the ground. Therefore, when train operation schedule has been disordered, it is systematically adjusted by COMTRAC. By reading the train number information, train groups can be managed.

On narrow-gauge lines, the traffic is controlled by the Program

1068 Computers in Railways

Route Control (PRC) system, Centralized Traffic Control (CTC) and other systems. Though there are various train control methods for narrow-gauge lines, even a complicated control system don't use the train number information sent from trains to the ground.

When train information (train number, train classification and other information) is transmitted from trains to the ground, the signalling systems such as traffic control, passenger information and level crossing control, which are under serious problems on narrow-gauge lines, will be come more intelligent, and train groups can be controlled.

In this paper, we report on an intelligent signalling system which adds a transmission function of train information to the existing on-board equipment for frequency shift type Automatic Train Stop (ATS) system. We also report the examination results of applying the system to level crossing control.

2 Traffic Control

2.1 Traffic Control for Shinkansen

On the Tokaido Shinkansen line, traffic is controlled by the Computer aided Traffic Control (COMTRAC) system as shown in Figure 1. COMTRAC also performs automatic route control, display of the train movement situation, operation arrangement support in the timetable disorder and other functions. The train number sent from a train to the ground is used for automatic route control. The train number information set on the train is received by the ground antenna located at a certain distance before the station, and is given to COMTRAC system by way of CTC. In the COMTRAC system, a route is set after the system has checked whether the train number read at the Train number detecting point (N point) agrees with the train number chased on the timetable.

Also, the train number information read at the N point is transferred to the Passenger Information Control system (PIC). The automatic public information system at the station is automatically controlled by this information.

When the train operation is disordered, it is arranged by train dispatchers with the support of COMTRAC. In such a case, key information for traffic control is the train number received at N point.

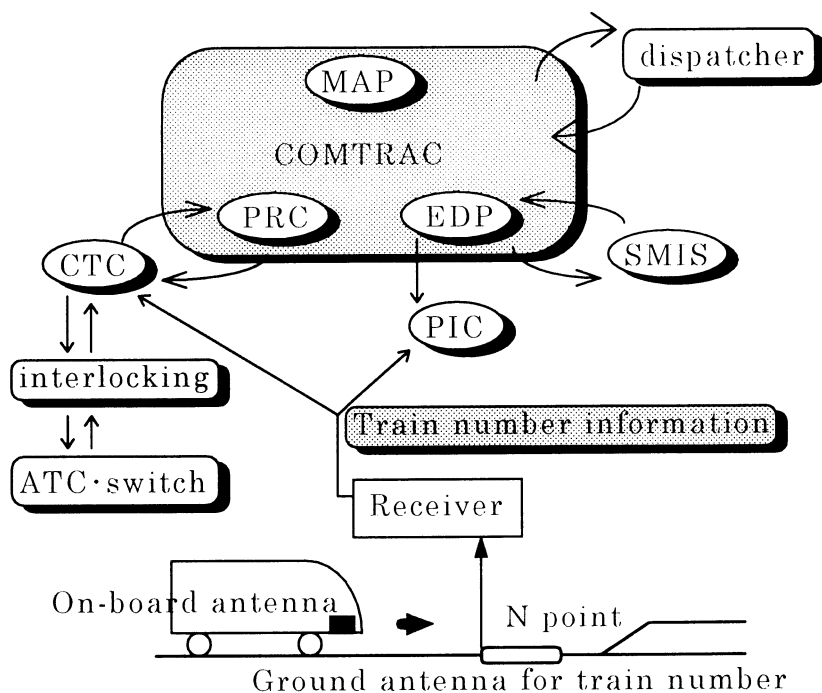


Figure 1: The whole structure of COMTRAC

The train number is set using a setting device at the vehicle cab. The ceramics resonator is connected with the on-board equipment, and its resonance frequency is changed by the switch of the setting device at the vehicle cab. On the ground, electromagnetic wave from the ground antenna is emitted to the on-board antenna with different frequencies. The ground equipment detects the resonance frequency of the ceramics resonator of a passing train and deciphers the train number.

2.2 Traffic Control of the narrow-gauge lines

On the narrow-gauge lines, where PRC is introduced, routes are automatically set. PRC sets a route automatically according to the preset program. The data required to control route setting are on the computer memory. Even if PRC hasn't been introduced, a dispatcher at the CTC center sets a route at the CTC lines. On the non-CTC lines, a route is set by a dispatcher at the signal box of each station.

At present, CTC has been introduced in a number of lines. But

1070 Computers in Railways

trains are tracked by train schedule on the timetable and their comparison with occupancy information from track circuits. However, train numbers of actual train can not be checked, as the train number information is not given to the ground from trains.

At present, a transponder system has been introduced into some lines in Tokyo, Osaka and other areas. By using a transponder system, it is comparatively easily possible to send the train number information. However, this system is too expensive to use on narrow-gauge lines on a large-scale. Also, as for most of narrow-gauge lines of all JR companies, the transponder system hasn't been introduced.

3 The Train Information Transmission Device

If it is possible to transmit the train information from trains to the ground, trains can be tracked based on the train number. Such a system has the following advantages:

- (1) Trains entering a CTC line from a non-CTC line or trains approaching a station in the non-CTC line are automatically recognized, even when the traffic is disordered.
- (2) If information on the brake performance and the running speed of the train is transmitted in addition to the train number, the level crossing warning time can more properly be set up.
- (3) When a ground antenna is set before the site of track maintenance, it is possible to know the train number will pass the site. This is effective for accident prevention, particularly when the traffic is disordered.
- (4) If train numbers are transmitted to a station, it will be used for passenger information.

When a transponder is used, the above function can be realized. As the transponder is expensive, however, it is not easy to introduce it into narrow-gauge lines on a large-scale.

Therefore, we have newly developed a device to transmit 40-bit digital information from trains to the ground at low costs. This equipment that uses the Automatic Train Stop (ATS) systems already introduced into all JR lines.

3.1 The Present ATS Equipment

Figure 2 shows the mechanism of ATS. When a train (with an ATS antenna on board) passes the caution point (ATS ground antenna) of stop signal, the crew member receives a caution from the ATS system independent from the current train speed. If the crew member doesn't perform confirmation operation within 5 seconds after receiving the caution, the emergency brake works.

103kHz or 105kHz is always oscillated from the ATS on-board equipment and is supplied to the primary coil of the on-board antenna. This frequency is received by the secondary coil and the main control relay (MR) works. An ATS ground antenna (within a resonance frequency at 130kHz) is installed at the caution point of stop signal. When the ATS on-board antenna approaches this ground antenna, the frequency of the ATS on-board equipment changes to 130kHz, the MR relay falls, and the train brakes are applied. Incidentally, when the signal is not for stop, the resonance circuit of the ground antenna is closed. Therefore, the ATS ground equipment doesn't have influence on the ATS on-board equipment.

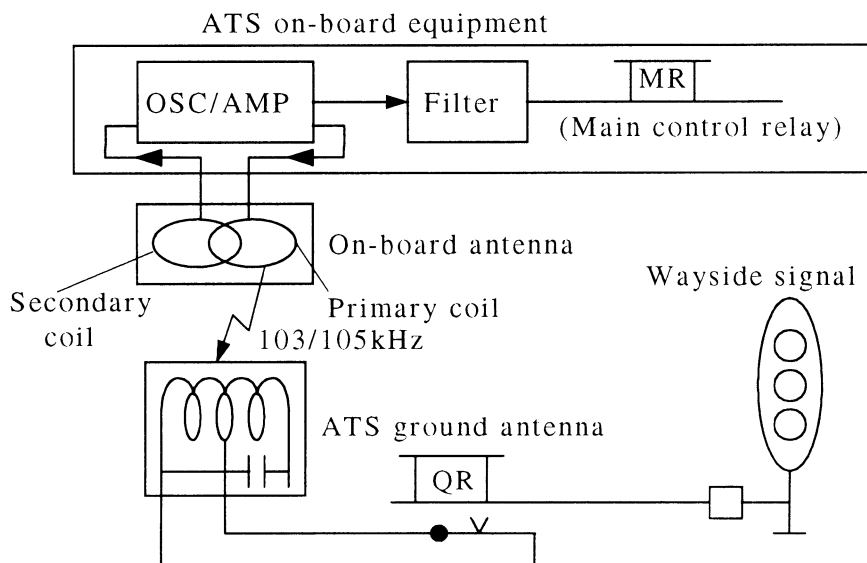


Figure 2: Mechanism of ATS system

1072 Computers in Railways

3.2 The Digital Information Transmission Device

The digital information transmission device is composed of the on-board equipment and the ground equipment in Figure 3.

Train information is transmitted from a train to the ground in the HDLC-based telegram format shown in Figure 4. A telegram length is 72 bits. Information contents are 8bits as the telegram classification, 12 bits as the train classification information and 20 bits as the train number information. The train speed which this device can correspond to is 140 km/h, which is the present maximum cruising speed on narrow-gauge lines. It is possible to receive at least 4 telegrams in one unit of transmissions between train and ground. The transmission area is prescribed 320mm or over at the present device. Then, we designed the ground antenna for the transmission area at 320 mm or over. We set transmission speed at 48kbps, considering train speed and information transmission quantity. The carrier frequency is 360 kHz. The deflection frequency is 12 kHz and the modulation method is Minimum Shift Keying (MSK). From the carrier, we excluded the frequencies used in the present ATS system. We adopted 360 kHz, as there are few losses in this frequency range. We confirmed that this frequency doesn't influence the function of present ATS.

The carrier frequency for the transmission from the receiver to the processing unit is 370kHz; the deflection frequency is 4kHz; the modulation method is Frequency Shift Keying (FSK) and the transmission speed is 1,200bps. The transmission speed is slower, because an information wave is overlaid on the power supply wave. To build the system at low costs, we are using power supply lines which are already underlaid in the area along the railway line as the transmission route from the receiver to the processing unit.

As a result of a long-range field test, the frame error rate of the transmission from trains to the ground was 6.34×10^{-4} . The target of the frame error rate is 2.16×10^{-3} , which is the frame error rate of the transponder. Therefore, the result of a long-range examination was below the targetted frame error. It was confirmed that there were no problems in transmission.

As for the analog characteristic, both the S/N ratio and the transmission area were satisfactory.

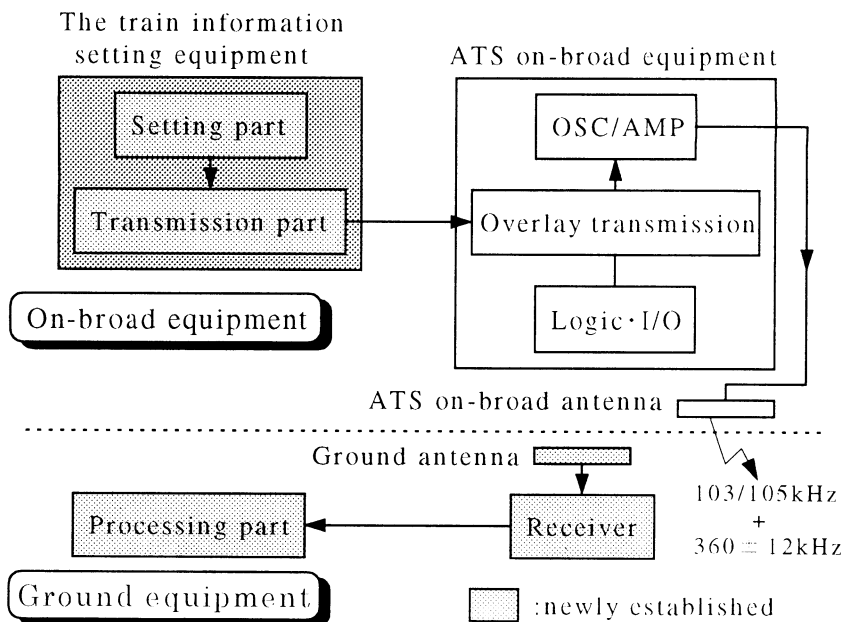


Figure 3:Structure of the
Digital Information Transmission Device

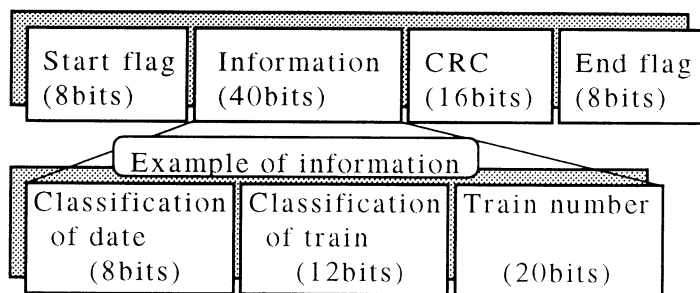


Figure 4:Data Format

4 Application to the Level Crossing Control

4.1 Problems in the Level Crossing Control

High density train operation and increase in the car traffic volume have caused a problem that the crossing warning time becomes long. A departure signal at a station of all JR companies is often "normal proceed aspect" even to stopping trains. Stopping time, acceleration time and deceleration time are added to the level crossing warning time near the station. Therefore, the level crossing time becomes long. To solve this problem, trains passing the station shall be distinguished from these stopping at the station. In case of the stop train, it is necessary to control to delay a caution beginning point.

To find out train behavior at a station, several ways are thought of. As one means, there is a way of transmitting train information from trains to the ground. If the digital information transmission which uses present ATS is used in this case, it is possible to improve the function easily and there is an excellent characteristic from the viewpoint of cost performance.

4.2 Application to the Crossing Warning Time Control

Figure 5 shows an outline of application to the level crossing control. The processing unit judges "passage/stop" of the train based on the train classification information which is received on the side of level crossing warning beginning point (the 1st start point) for passing trains. Only when it is judged that the train will stop, the caution circuit of the level crossing control system is masked. Also, when it is judged that the train will stop, the train speed is watched by the ground antenna to verify its speed. When the speed exceeds the verification speed, emergency brake is worked.

A ground antenna for passage/stop distinction is placed before the point to start warning for the present level crossing. If it is judged that the train will not stop when the train passes this ground antenna, the level crossing control begins from the prefixed point. If it is judged that the train will stop, the level crossing control begins after the train has run for a certain time length.

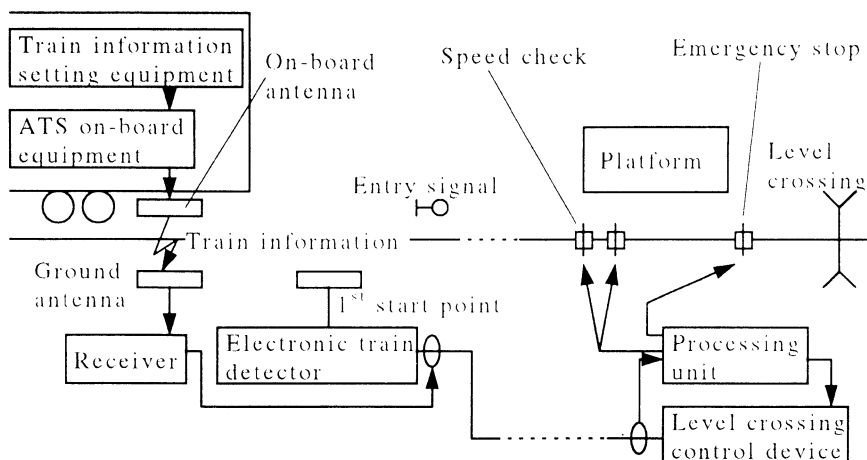


Figure 5:Outline of Application to the Level Crossing Control

4.3 Estimate of the Effect

As for an actual level crossing, we investigated the present crossing warning time, and estimated the effect of the abridgment of the crossing warning time, when trains are sorted, that is, "passage/stop" are judged. The general condition of the level crossing is shown in Figure 6. When the main track leaving signal (22L) is not a stop signal, it is established both for the passing trains and stop train to begin a warning from the crossing warning beginning point (ADC).

By installing a ground antenna on the Mojiko side of ADC and judging the train type there, we estimated the effect of beginning the crossing warning after the train has entered ILAT and run for 30 seconds.

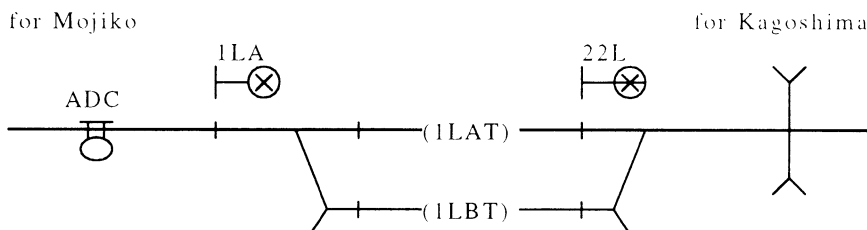


Figure 6:General Condition of the Level Crossing

1076 Computers in Railways

In the present case, because there are a number of trains which stop on the main track, a peak is seen in the warning time at about 2 minutes and 20 seconds. When an up train and a down train are involved, warning sometimes lasts for about 6 minutes. On the other hand, when trains are sorted, the warning time tends to become shorter on the whole. When incidences where the warning time is shorter than two minutes are counted, for example, they account for 61% of the total at present, which will be increased to 90% , if the system introduced in this paper is adopted.

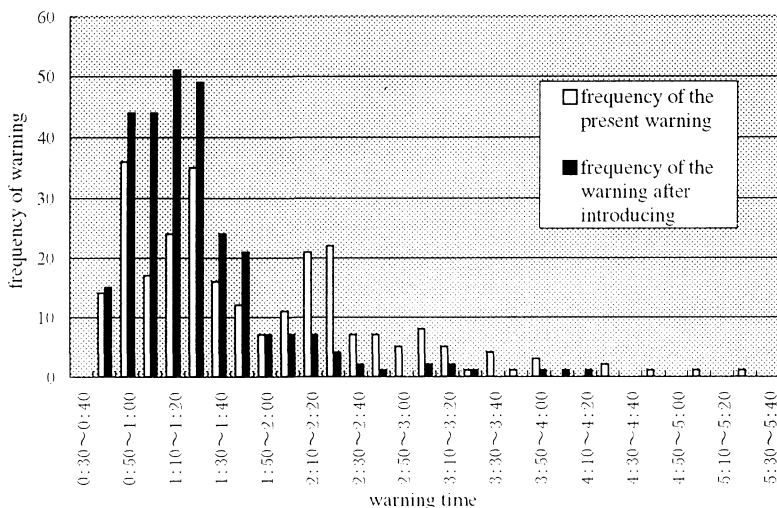


Figure 7:Effect Estimate of the Crossing Warning Time Control by the Train Sorting-out

5 Conclusions

We developed a digital information transmission device which uses ATS. This is the equipment to transmit train information to the ground system at low costs. We confirmed that the level crossing warning time could be controlled by using this system. In this paper, we have described an application to the level crossing control. If this equipment is used for signalling systems, the signal facilities will become more intelligent.

References

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