Improvement of the Interference Performance of Low-frequency Track Circuits by Simple Code Transmission

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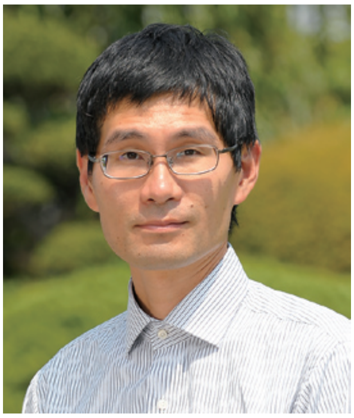

1. Foreword

The current necessary for driving electric rolling stock flows from overhead wires, then passes through vehicles and rails before returning to substations. However, there is a possibility that the current may induce a malfunction of the track circuits. Although allowable values have been specified for vehicles so that track circuits do not malfunction even in abnormal situations such as broken rails, there are some low-frequency track circuits which have small allowable values, and this has started to restrict the development of new vehicles. Accordingly, RTRI studied/investigated ways of preventing malfunction in abnormal situations, by encoding track circuit signals and verifying the code with a simple method so as to increase allowable values. Then, RTRI experimentally manufactured the equipment and performed the validation.

2. Outline of measures to prevent interference

In its investigation of ways to prevent interference, RTRI considered the use of simple encoding without changing signal frequencies, and studied/investigated a method that minimizes replacement of the equipment, as far as possible. Finally, RTRI adopted BPSK (Binary Phase Shift Keying) modulation by switching the polarity of transmitted signals through the use of a semiconductor switch, according to the codes (Fig.1). A modulator is added, while the conventional transmitter is used without change. Although the receiver has to be replaced, it is not necessary to replace the peripheral equipment on the rails (Fig.2). Regarding the codes, the speed of operation was increased by continuously flowing fixed codes in a seamless manner, and by starting to read the codes from an arbitrary position at the receiver. There is no fixed code, and the code is chosen so that any shifted code can be treated as the same code.

RTRI studied/investigated codes, modulation speed, and the verification method under a condition where the track circuit was configured with a length of up to 5 km, using a frequency of 25 or 30 Hz. (1) The time required for the track circuit to operate from the cut-off status when the train began moving is set at about 2 – 3 sec. (2) The probability of malfunction caused by interference where the track circuit should normally be cut off at the imbalance of 100% is set at about $1 \times 10^{-9} - 10^{-10}$/h. (3) In the case of setting the C/N (carrier to noise ratio) at 10 dB and the BER (bit error rate) at 2.27×10^{-5} in the normal state, the probability of track circuits being operated incorrectly due to interference where the track circuits should normally continue to operate, is set at about once in 100 years, and in 100 track circuits.

3. Evaluation by RTRI

Through the use of prototype equipment, RTRI validated the characteristics regarding transmission/reception levels and the characteristics regarding short circuits, and confirmed that there is no change compared with the conventional characteristics.

In addition, RTRI also evaluated the transmission error characteristics. RTRI evaluated the characteristics for sinusoidal disturbance and white noise disturbance (Fig.3), and confirmed that no problem exists even if the current data obtained at a substation is reproduced as additional disturbance.

4. Evaluation by tests at the site

RTRI provisionally installed the test equipment on a commercial line and operated it for about one month. Although the distance was 6.17 km rather than the 5 km used in the tests, RTRI confirmed that transmission was definitely performed, and also confirmed that train detection was carried out in the normal way. The BER was 2.77×10^{-5}, which was smaller than the assumption in the experiments. However, it is considered that this is because the interference generated by the vehicles was small. Regarding the operation of the track circuit when the train began moving, the time taken to operate was also confirmed to be two to three seconds.

5. Conclusion

By applying this technique, the allowable value was able to be set as 0.9 A instead of 0.3 A, and the effectiveness was confirmed. From now on, RTRI plans to promote practical application of the technique. Further, BPSK modulation can be used to carry multiple information on the track circuit, but this is a future challenge.

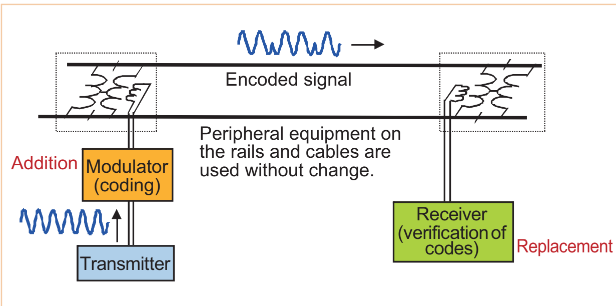

Fig.2 Application method of interference countermeasures

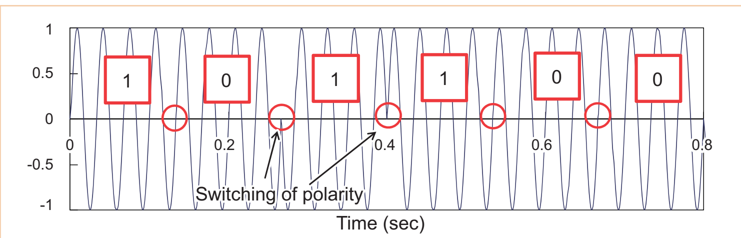

Fig.1 BPSK modulation waveforms by polarity switching

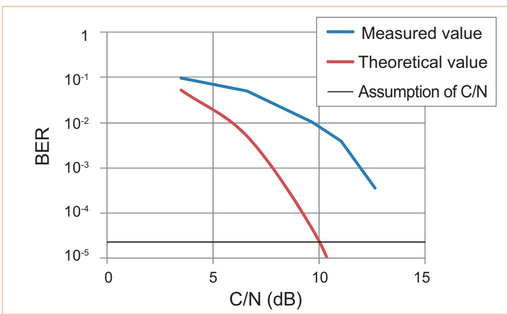

Fig.3 BER against the white noise