Development of a Low-Frequency Track Circuit with Improved Noise-Resistant Features

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1. Introduction

To improve the efficiency of signaling systems maintenance/construction work by integrating track circuits of different types and to enhance the efficiency of the development of rolling stock by making track circuits insusceptible to the influence of return current ‘downstream’ of trains that are running, RTRI has developed a highly noise-resistant low-frequency track circuit. This is intended to be used for different tracks regardless of their conditions, thereby facilitating the aforementioned integration of track circuits.

2. Discussions to make the new track circuit immune to track conditions

To make the new track circuit adaptable to any line conditions, the circuit length shall be about 2.0 km or the same as that of existing track circuits. This requires carrier waves in comparatively low frequency bands.

To ensure noise-resistant performance in the environments of DC and AC(50/60 Hz) electrified systems, the frequency of the track circuit shall avoid frequencies that are the same as or an integer times as high as that of the frequency of the electrification power supply (50/60 Hz) or those in frequency bands lower than 50 Hz. For these reasons, the author adopted the three carrier waves in Fig. 3.

3. Guarantee of the noise-resistant features

To guarantee the noise-resistant features and prevent the wrong-side failure if something unusual should occur, the author adopted an MSK modulation method to code track circuit signals and perform code tests. This makes the allowable return current 1 A or higher in each frequency band, thereby solving the problems otherwise anticipated in developing rolling stock.

On the other hand, as high speed transmission is difficult in the frequency bands in Fig. 1, the author adopted a cyclic code method to enable the reception of cordword in a short period of time (Fig. 2). The cyclic code method recognizes bit strings that have rotated a codeword as the same as the original codeword. This makes synchronizing from any position of bit strings. The author also took advantage of the special features of cyclic codes to devise a method to implement codeword verification by sectioning the massage frame at arbitrary bit positions irrelevant to the fixed massage frame (Fig. 3). With the help of these methods, the author achieved a sufficiently high capability for codeword verification while maintaining the time taken to operate the track circuit at the present level.

4. Verification through a field test

The author overlaid a prototype track circuit of the type described onto an existing track circuit used for a revenue service line for a one-month monitoring test. This field test verified that the prototype functioned in a stable manner while recording no disagreements in train detection with the existing track circuit. Furthermore, the bit error rate originally designed as 1.0×10^{-4} was as low as 1.0×10^{-6} or less, so verifying that the new track circuit has sufficiently high transmission quality and excellent performance for practical applications.

5. Conclusion

Introduction of signalling systems without track circuits has long been called for. Nevertheless, the needs of railways still relying on track circuits remain unchanged. The author wishes to promote research on systems using new media and to apply new technologies to conventional track circuits and equipment, thereby aiming at contributing to the improvement of safety and reliability of signalling systems.

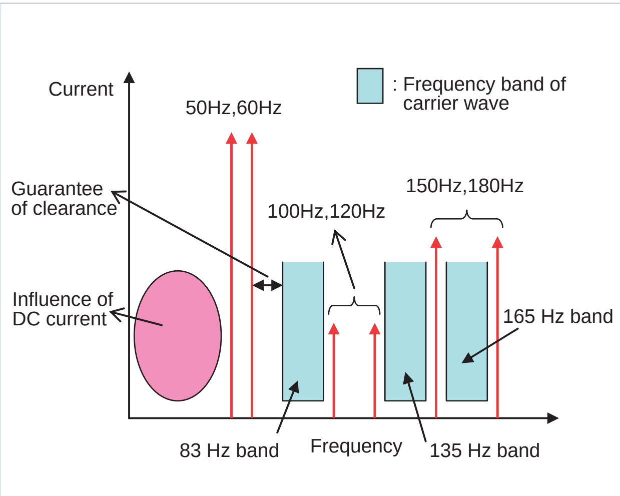

Fig. 1 Frequency band versus power source harmonic noise

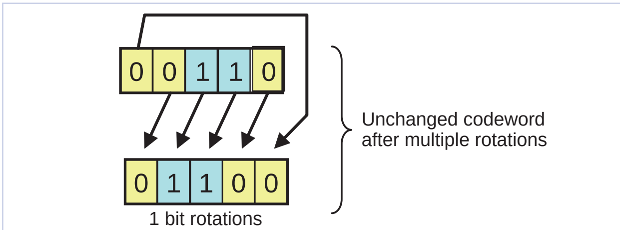

Fig. 2 An image of the cyclic code method

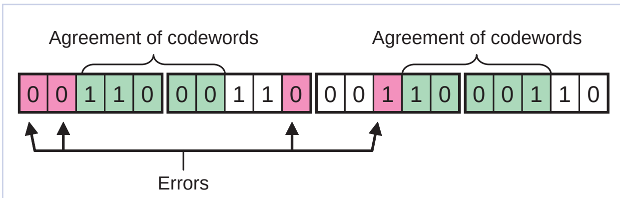

Fig. 3 An example of the test at an arbitrary frame position