Research and application of information transmission of high-speed railway train control system

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1. Transmission characteristic introduction

1) Track circuit transmission

- Medium: rail loop, antenna of cab signal
- Insulated mode: jointless track circuit, electric insulation
- Signal modulation type: FSK
- Character code: 18, from 10.3Hz to 29Hz
- Carrier wave: 1700Hz, 2000Hz, 2300Hz, 2600Hz
- General transmission length in the section: 1000~1200m
- Minimum rail short current: 500 mA
- Maximum rail traction return current: 1000A
1. Transmission characteristic introduction

2) Spot balise transmission

- Medium: balise, antenna and BTM unit
- Signal modulation type: FSK
- Frequency modulated rate: 564.48 ± 2.5%kbit/s
- Carrier frequency of down-link air-gap: 27.095MHz ± 5KHz
- Whole code length of telegram: 1023bit
- User bits: 830bit
- Balise type: Standard size, active reference area: 358 mm × 488 mm
1. Transmission characteristic introduction

- 3) Radio transmission
  - Medium: GSM-R system
  - Transmission type: circuit switching, asynchronous and transparent data transmission
  - Transmission rate: 4.8kbit/s
  - Minimum receiving electric level: -92dbm
  - Frequency domain: 885-889MHz, 930-934MHz
  - Distance between two adjacent BTS: 3~5km
  - GSM-R network structure: interlaced and redundant
2. Potential factors analyse related to train running speed

Potential factors:

- Active time: the coding and response time of Cab signal,
- Active area: the acting area of balise, the number of continuous and exact bits
- Electric interference: wave quality, sensitivity, data error rate,
- Time delay of transmission: delay of end to end data transmission
- Other parameters: signal power, frequency spectrum and telegram, the shortest distance of track circuit section, unbalance traction return current, the time of transmission interference, etc.
3. Transmission performance special test in China

Summary of test:

1) During Jan~Aug, 2009, special test, Wuhan-Guangzhou high speed test line, the maximum testing speed is 350km/h,
   • Receiving signal quality test of balise telegram,
   • EMC test of the equipment on board
   • GSM-R transmission performance test

2) During Dec, 2010~Mar, 2011, the comprehensive test of signal and communication system, Beijing-Shanghai test line, the top testing speed is 420km/h,
   • Receiving quality of cab signal;
   • Conveying performance of balise telegram
   • Transmission speciality of track circuit
   • Propagation characteristic of GSM-R, data exchange service and service quality of packet domain of GSM-R, service quality of circuit domain of GSM-R and the transmission characteristic of train control information etc,
3. Transmission performance special test in China

1) Test of receiving quality of cab signal

- The test section of cab signal has covered all the typical bridge and ballastless track structure in railway station or section, include 4 kinds of carrier frequency of track circuit section just as 1700Hz, 2000Hz, 2300Hz, 2600Hz, the design length of track circuit section is 1000~1200m currently, the length of electric insulated section is 32m, the test speed include 250km/h, 300km/h, 330km/h, 350km/h, 370km/h, 380km/h, 390km/h, 400 km/h, 410km/h and 420km/h.

- A great deal of test about the special running operation had been done, which especially aimed at the receiving and coding performance test of Cab signal on the conditions of various special interference, for example, Main transformer break or close, EMU Pantograph lowered or raised, Unbalance rail etc.

1) All the cab signal amplitude satisfy the demand of receiving sensitivity;
2) It don’t bring more bad influence clearly on cab signal receiving while the main transformer broken or closed;
3. Transmission performance special test in China

- 2) Transmission test of balise telegram

The transmission test of balise telegram aim at the correlation research between the number of bits received reliably, data error rate of Eurobalise telegram and train running speed, balise installation, on the basis of the test and analyse on the signal power, frequency spectrum and balise telegram of the up-link message, the final purpose of that is to give an exact appreciation on the adaptability of balise transmission at high speed.

Including transversal and longitudinal mounting, five sorts of installation height, the distance from top of balise to top of rail are 93mm, 130mm, 170mm, 195mm, 218mm separately, the trial speed are 250 ± 5km/h, 300 ± 5km/h, 350 ± 5km/h, 380 ± 5km/h, 400 ± 5km/h and 420 ± 5km/h.

1) The method of longitudinal mounting in the whole main line section of Beijing-Shanghai line is certain, the distance from top of balise to top of rail is 130mm;
2) When the trial speed reached to 420km/h, the minimum number of continuous and correct bits that BTM on board had received actually is 2128 bit,
3. Transmission performance special test in China

- 3) Test of high speed adaptability of GSM-R for CTCS-3 message

The performance test of service quality of CSD are consisted of the kinds of parameters, including the delay of communication connecting, the probability of connecting failure, the delay of end to end data transmission, the probability of connecting lost, the time of transmission interference, the time of no error transmission etc.

The parameters that may bring bad influence to the message transmission of automatic train control system are mainly comprised of the delay of end to end data transmission, the time of transmission interference etc.

1) On the condition of two kinds of transmission rate 4.8kb/s, 2.4kb/s separately, and the train high speed running, the statistics value of the delay of end to end data transmission have few or no difference

2) It can draw a conclusion that there are few relationship between the delay of end to end data transmission and the transmission rate
4. Comprehensive application of the kinds of transmission methods

- **Comprehensive application**
  - In order to develop the advantage of the kinds of transmission methods, to strengthen the reliability of message conveying, the three kinds of transmission methods above had been used comprehensively in CTCS-3, which built a new mode that the message transmission mainly rely on GSM-R, the track circuit and spot balise provide intermittent and continuous assistant information to train, this mode is called “Dian-Lian” mode commonly, which also satisfy the message requirement of CTCS-2 at the same time.

- 1) The double safe data transmission connection between train and wayside system through the interface I_fix and I_gsmr will be established, the RBC will send movement authorities, as well as information about permanent and temporary speed restrictions, line gradients, track conditions and route suitability etc to trains;

- 2) CTCS-3 and CTCS-2 use in common the balise, the wayside intermittent system integrated the telegram of CTCS-3 and CTCS-2, Apart from the function of train orientation to CTCS-3, there are some message packets only for special functions of that, for example, ETCS-131,ETCS-137,ETCS-132,ETCS-41,ETCS-42,ETCS-46 etc;
Data and picture

Figure 2  The signal wave of minimum amplitude in the section

Figure 4 Relation between train speed and the number of continuous and correct telegram
...Thank you for your kind attention