China Railway Radio Interference and Protection

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Abstract

China Railway has built about 20,000 kilometers GSM-R lines. With the fast development of wireless application, there is more interference from its own network and public operators. Introduction of current China Railway GSM-R network interference, way to detect these interference and protection methods is briefed.

1. Introduction

Wireless Communication is convenient to people and of great importance to guarantee railway effectiveness and safety. At present, China Railway (GSM for Railways) GSM-R communication system bearing the train control information serves as a basis for train safe operations. The more lines implements GSM-R system, the more serious wireless radio interference problems is, which is a hidden trouble to China railway wireless communications. China railway plans to implement GSM-R system to both high speed and conventional lines then there are more and more parallel tracks and cross areas where highlight the wireless environment problem. This article introduces the China Railway current GSM-R wireless environment and how to solve the problem.

2. Interference and its type

At the beginning period of railway construction, the main problem of wireless environment is to clear frequencies and eliminate illegal radio stations along railway lines engaging on GSM-R frequencies in order to build a strong foundation for railway GSM-R system. In the past, China railway GSM-R and public mobile networks coexisted on GSM-R frequencies. And public operators using the lower frequencies are more likely to cause inter-modulation. Thereupon, the first target for newly built lines is frequency clear.

Further new lines in some areas have intersection with conventional lines without considering the inter-network interference comprehensively. Also, public mobile operators optimize their coverage along railway line to satisfy passenger needs which influence GSM-R system to some extent and make it even harder to pinpoint interference.

As shown in Fig.1, it is a circuit switching data (CSD) QoS test of a train running in two directions at the same line and the same area. We could tell the difference is the quality before handover is poor at the up-direction, and at the down-direction the quality after handover is poor. In the view of frequency planning, the two base station (BS) frequencies could inter-modulate to the neighbor BS frequencies. This could arise QoS problem which shown in

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communication inspection. Still, there is a need for proper methods to dig out the exact reasons and the types of inferences then to mitigate the interference.

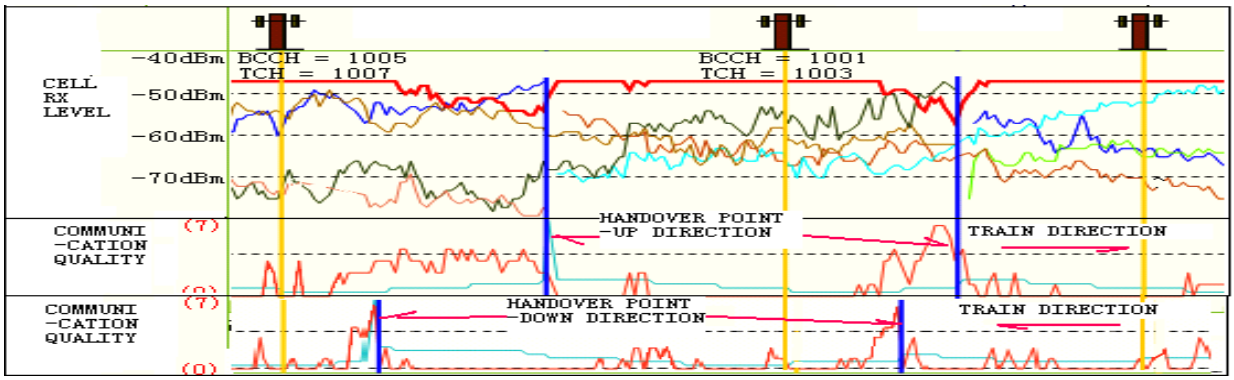

Fig.1: display of QOS inspection curves

The QoS quality used to be very good along the whole line between zhengzhou and Xi'an. However, after establishing Xinfengzhen marshalling station and Baotou-Xi'an line，it is the intersection area with Baotou-Xi'an lines, and then communication quality is greatly affected. These are only intro-network interferences. Public network operators also interference with China railway GSM-R network at many locations, for example, Bengbu South area along Hefei-Bengbu high speed railway, and Hefei Station area which is an intersection among Hefei-Wuhan, Hefei-Nanjing, Hefei-Bengbu high speed railways lines. And at some well-developed economic area along the lines, there are more interference affected railway networks.

At the Hefei station, public wireless operators add more equipment specifically along the high speed lines to reinforce the wireless magnetic coverage to provide better services for customers. These new signalers along with old ones cause interferences to China railway GSM-R network. It is checked that all the equipments of the public mobile operators in the area are all qualified; still, in GSM-R test mobile terminal dropout, ping pong handover, poor communication quality appear due to inter-modulation. Then, China Railway operator had installed filters at GSM-R mobile terminals in this area which effectively mitigate the interference. This proves the existence of inter-modulation.

3. interference inspection

3.1 Drive Test(DT)

The interference inspection is routine for GSM-R optimization. At present, DT is a usual way to find the C/I abnormal and Rxqual low areas.

Geographic eviorment can be seen from digital maps in drive test combined with other information which is a method to locate the interference signal at large. Drive test is just a way to measure communication quality which could not only effected by natural eviroment but also network parameters, equipments and so on. Thereupon, the existence and source of interference need to be proved and pinpointed along with other methods.

3.2 frequency spectrum measurement

Recent years computer technology development further spectrum analyze technology. Real time sprectrum analyzers apply Digital Phosphor Spectrum (DPX) technology which improves spectrum refreshing ability to 50000 times/s, so as signals with more than 20 microsecond dell time could reach 100% probability of identification (POI). This kind of anlyzers have started to be used in interference inspection overseas now.

Real time sprectrum analyzer could distinguish low-level signals at different time sharing the same frequency and its level and probablity when detecting co-channel interference[1]. In this method, we could find out wheter the signal from picture 1 is co-channel interference or not.

3.3 scan and decode

Sprectrum analyzer could only detect illegal GSM-R frequencies. However, it is uncertain where the interferences come from especially to the public operaters who have qualified parameters but still interfere with GSM-R systems.There is nothing can be done by only applying frequency analyzer. At present ,we often use scanner with signalling decoding function to detect interferences. This kind of scanner could inspect demanded wireless signalling and then find out RXlevel, C/I, cell belonging, cell number, BISC and so on within one area. It could detect interferences in or out of railway GSM-R system.

In a scanner decode test of a dual base stations (BS) at one station site along a high speed railway line. In the test BCCH of BS A is too bad to satisfy the GSM-R requirments(C/I>12dB), and quality of BS B is good. DT shows that mobile terminal is at BS A though QoS is pretty bad, still no handover occurs. Through scanner decode test, we know in this area BS B is good, and BS A is interfered. Then, Network parameters could be adjusted by given BS B the priority to guarantee communication. This can not be seen from DT which could only inspect the communication quality of current service cell. In this case, the performance of BS with BS B can not be inspected through DT.

4. Protection

4.1 GSM-R network optimization

Network optimization is a basic job to prevent interferences. Then we move on to network planning and frequency optimization. At first, a reasonable BS planning is needed. It is not true that the more BS in use, the better network performance because every BS in some point is an interference source, unreasonable construction could make it conter-benefit. At present, there are many dual BS at one station site at many railway line intersection area, however, the benefit is not clear, and the interferences appear more in such areas.

Frequency optimization is of great importance to GSM-R planning. Though China railway GSM-R system is not complicated as public wireless networks, it still required scientific planning, especially more consideration are needed at central busy station and mutil-prarall line areas. As shown in picture 1 or similar cases, inter-modulation could be avoided if no equal-gap frequencies are used in neighbouring base stations.

4.2 network parameters adjust

The main function of China Railway current GSM-R network is to guarantee high speed train operation safety. It is required in railway regulations that GSM-R network do not implement terminal power control and non-continuous emission technology to avoid interruption to train control datas transmmision due to power and transmitter emmision flunctuation. The regulation and its application is the same to Europe GSM-R network. Considering interference control and operation characters of different lines, we are thinking of adjusting these regulations according to the that different lines have different network technology requirments.

To the further low-speed line, we could implement automatic power control and non-continious emission technology. To low-speed line such as under 160 km/h, railway users mainly use voice comminucation along with GPRS

data communications. To voice communication, short-interval voice change is not quite visible to users. The attempt to start auotmatic power control to imigarate radio interference would barely influence train dispatching communication.
Automatic power control can be divided into downlind and uplind power control. In order to reduce the interference as much as possible at the same time guarantee communication quality, tuning down the BTS power could lower the probability of co-channal interference, and it is effective to improve communication quality reducing mobile terminal power around BS. So, automatic power control technology is an effective way to mitigate GSM-R intro-network interference[2].

Except power control, emission at intervals could also mitigate interference. In the communication between network and mobile terminals, at the voice intervals, it is not nessasary to send signals, non-countinous emmision DTX is needed. When using DTX, network must judge if there is voice signal sending or not, because the begginning of a conversation could be effected. This is not allowed in CTCS-3 train control system.

DTX has its own advantages, such as mitigate the whole network interferances and improve average communication quality. Downlind DTX could mitigate system modulation interference effectively, then benefit railway central stations and multi-parallel lines. So, to the non-CTCS-3 lines, especially to the GSM-R network of other lower speed lines or around marshing station, DTX could garatee their own communication quality without interference to train signals within CTCS-3 system.

4.3 mitigate power radiation

To the users mainly suffering from intro-network interference system, any BS or mobile users is an interference source to them. Currently, railway BS radiation power is set to 48dBm which is the largest number as planned. In some area where frequency is not configured completely reasonable, the larger the radition is, the more inter-modulation to the neighbour cell would appear.

According to inter-modulation interference theary, at normal circumstance, third-order intermodulation level will reduce 3dB when 2 single carrier frequency level reduce 1 dB. It is required in China railway regulation, auotmatic power control can not be used in CTCS-3 system, so BS radiation power should be as low as possible under the condition of satifying communication requirements to greatly reduce intermodulation interference due to unreasonable frequency configuration to improve communication quality.

5. Conclusion

To mitigate radio interferences is one major issue of railway GSM-R communication. China Railway has been working in this area at construction and application. However, at network planning, test regulation, statistic analyze and evaluation, it is still at trial statge. We should strenghten the efforts on current interference inspection and statistic analyze to match up with the further larger rage of GSM-R network construction and embrace railway system application on new wireless communication systems.

6. References

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