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RISK EVALUATION OF COMMUNICATION AND ANTENNA MANAGEMENT FOR RAILWAY VEHICLE ANTENNAS

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ABSTRACT:

An evaluation method that is suitable for determining the electromagnetic compatibility of vehicle-mounted antennas is proposed as a means of ensuring that multiple vehicle-mounted antennas do not produce electromagnetic interference as a result of their integration on the same railway vehicle. This is done in order to verify that electromagnetic interference does not occur. The combination of antennas that has the potential to create electromagnetic interference is selected on the basis of an examination of the variables that generate interference caused by antennas, as well as the changes that occur in the electromagnetic environment both before and after loading. After that, the isolation that exists between certain antennas is assessed in order to enhance the results from the examination. Calculating the energy matching of transceiver antennas is the last step in determining whether or not two antennas are electromagnetically compatible with one another. The technology has been used in the process of designing and constructing railway cars.

Keywords: Railway vehicles; Evaluation method; Electromagnetic interference; Isolation

INTRODUCTION:

In recent years, there has been a fast growth of railway transit vehicles, which has resulted in significant social and economic advantages. Urban rail cars have played a vital part in this development, since they are a key component. As a result of the relentless march of technological advancement, railway vehicles have begun incorporating an increasing number of wireless technologies [1-2]. While this is happening, the potential for damage and danger posed by electromagnetic interference across different systems is becoming more apparent [3]. Multiple antennas are located on the platform of the train car, which has a very restricted amount of space, which increases the likelihood that common address interference may occur between the antennas. As a result of the appearance of electromagnetic interference issues, operators, signal system suppliers, communication system providers, vehicle suppliers, and other stakeholders are very worried about electromagnetic compatibility (EMC) in vehicles. When it comes to the design and implementation of rail transport vehicles, determining whether or not a vehicle is electromagnetically compatible has emerged as an essential component. At the moment, the conformity of electromagnetic compatibility of vehicles is primarily evaluated based on the electromagnetic compatibility test results, and the electromagnetic compatibility test is primarily carried out in accordance with EN 50121, which is designated as "electromagnetic compatibility of rail transit" [4]. The cable port and the chassis port are both covered by this standard; however, the antenna port is not covered. As a consequence of this, the testing group that was developed according to this standard is unable to immediately assess the electromagnetic compatibility between antennas once each wireless device has been loaded.

An electromagnetic compatibility (EMC) evaluation method that combines actual measurement and calculation analysis is introduced in this paper. The paper takes a railway vehicle project for a city as its engineering background. Its goal is to address the limitation that the electromagnetic compatibility compliance of a vehicle-mounted antenna cannot be directly evaluated using only testing.

COMMON ADDRESS INTERFERENCE PRINCIPLE:

Because an antenna is required for wireless devices in order to broadcast and receive usable signal electromagnetic waves, electromagnetic compatibility systems must ensure that antennas are mutually compatible with one another. Antenna mutual interference requires three foundational elements to be present: first, there must be at least one antenna acting as an interference source (which will be referred to in the following as the source antenna); second, there must be at least one antenna functioning as a sensitive body; and third, there must be at least one electromagnetic wave propagation path that enables electromagnetic disturbance to travel from interference sources antenna output port to sensitive antenna input ports. Above these three elements, the source antenna needs to emit electromagnetic disturbance with sufficient energy, so that electromagnetic disturbance can enter the receiving device, and cause the receiving device to fail work, in order for the phenomenon of antenna interference to take place at this time. Because the intentional transmitting power in the band used by the transmitting antenna is greater than the stray transmitting power, and the sensitivity threshold in the band used by the receiving antenna is also lower than the sensitivity threshold outside the band, if the interference path of multiple antennas has been formed after loading, three types of antenna interference may occur: the source antenna and the sensitive antenna work at the same frequency band, that is, the same frequency interval; the intentional transmitting power in the band used by the transmitting antenna is greater than When compared with the other two types of interference, it was found that interference at the same frequency is more likely to be found and is more common in the field of urban rail transit. For example, according to the

American association of electrical and electronics engineers 802.11 series of wireless local area network (IEEE802.11) technology standard of communication-based train control (CBTC) system and passenger information system (PIS), interference at the same frequency is likely to occur between the two systems.

ANALYSIS OF VEHICLE-MOUNTED ANTENNA:

The vehicle-mounted antenna serves as the evaluation object for a variety of different systems, including the vehicle-mounted equipment of the train control system, the vehicle-mounted equipment of the wireless communication dispatching system, the vehicle-mounted part of the PIS system, and the linkage system of the shielding door. Traditional signal systems and CBTC systems are also possible classifications for the signal system. The cbtc-rf system, which is based on radio frequency technology, is used in urban rail transit's train control system. Around 2.4 gigahertz is the operating frequency band of this system's onboard antenna's working frequency band. With S40, there is a ring that has cross sensing cable, also known as an inductive loop, and a two-way communication vehicle antenna that is created by electromagnetic induction coupling of CBTC - IL systems. For instance, the system's operational frequency for the on-board antenna might be anywhere between 36 and 56 kilohertz. Traditional signal systems often make use of a Track Circuit, axle counter, and many other pieces of train detection equipment, in addition to point-type transponders. These components, together with the transponders, are all mounted on the underside of the vehicle. In general, the frequency range of 1.7kHz-20.7kHz [8] is where the operating frequency of the on-board antenna of the domestic mainstream Track Circuit may be found. Onboard antenna is not required for axle counter operation. As an example, consider the transponder transmission module (BTM) of ctcs-2, which is a Chinese train control system. The operational frequency of the onboard antenna of this module is 27.095MHz and 4.234MHz. The land cluster radio (Tetra) communication system is extensively adopted for use in urban rail transit wireless communication dispatching systems. The frequency range of 806–866 MHz that is usable by the onboard antenna of this system is the operational frequency range. WLAN technology is also often used in the passenger information system (PIS) of urban rail transportation. Additionally, the Screen Door linkage system could incorporate WLAN technology. Additionally, the vehicle antenna has a working frequency range that is around 2.4 gigahertz in range. The information on vehicle-mounted antennas that was presented before has been sorted for ease of study.

EVALUATION METHODS:

A. Spectrum Planning Management:

The electromagnetic compatibility of the on-board antennas of urban rail transit vehicles is dependent not only on the availability of the necessary technical means, but also on the availability of the necessary managerial means. Because spectrum planning is such an essential component of the effort that goes into ensuring electromagnetic compatibility at the outset of system design, the assessment process also begins with the examination of spectrum planning. First, it is necessary to get the spectrum that is occupied by each wireless system, the installation location of any antennas that are placed on vehicles, the interface between the systems and their respective operating principles, etc. The information that is collected has to be as detailed and exhaustive as is humanly feasible in order to include all wireless devices. This is necessary in order to guarantee the authenticity of the evaluation's contents and the precision of its findings. After gathering this essential data, it is then calculated, and the antennas that operate within the same frequency range are screened and categorised accordingly. The next thing we need to do is examine the design document to see whether it has any anti-interference safeguards. If there are anti-interference measures, their application will be assessed, assuming there exist such measures. The compatibility of these antennas will be indicated as the risk item that has to be evaluated if anti-interference measures are not applied, or if the measures are not applicable. In the final step of the internal interference test of vehicles, the effectiveness of anti-same-frequency interference measures of wireless equipment is checked. This is done by working simultaneously with pairs of antennas and monitoring the functional performance of wireless equipment of the test subjects. The antenna that is listed as a risk is the one that is focused on.

B. Energy Matching Assessment:

The electromagnetic compatibility of the on-board antennas of urban rail transit vehicles depends not only on technical means, but also on managerial means in order to function properly. Since spectrum planning is an essential component of the electromagnetic compatibility work that must be done at the outset of system design, the evaluation work must also begin with spectrum planning inspection. In the beginning, it is necessary to collect the spectrum that is occupied by each wireless system, the installation position of vehicle-mounted antennas, the interface between the systems and their operating principles, and other relevant information. In order to maintain the reliability of the evaluation's content and the precision of its findings, the information gathering process must to be as detailed and exhaustive as is practically feasible. All wireless devices have to be included. After gathering this important data, it is then entered into a spreadsheet, and the antennas that operate in the same frequency range are filtered and grouped together. The next step is to examine the design document to determine whether or not it has anti-interference safeguards. In the event that there are anti-interference measures, an examination of how well they work will be carried out. If no anti-interference measures are applied or the measures do not apply, the compatibility of this set of antennas will be classified as the risk item for review and will take its place at the top of the priority list. Finally, in the internal interference test of vehicles, the effectiveness of anti-same-frequency interference measures of wireless equipment is checked by working simultaneously with pairs of antennas and monitoring the functional performance of wireless equipment of the test subjects. The antenna that is listed as a risk is the one that is focused on.

$$C(f) = 10\lg(Pt(f)/Pr(f)) \qquad (1)$$

Where: C(f)—spatial isolation between two antennas, dB;

The electromagnetic compatibility of the on-board antennas of urban rail transit vehicles is dependent not only on the availability of the necessary technical means, but also on the managerial means. Because spectrum planning is such an essential component of the effort that goes into ensuring electromagnetic compatibility at the outset of system design, the assessment process also begins with spectrum planning inspection. To begin, it is necessary to get the spectrum that is occupied by each wireless system, the installation location of vehicle-mounted antennas, the interface between the systems and their operating principles, and other relevant information. The information that is collected need to be as detailed and exhaustive as is humanly feasible in order to cover all wireless devices. This is necessary in order to guarantee the authenticity of the assessment's content as well as the precision of the conclusions of the evaluation. After gathering this essential data, a tabular representation of it is then created, after which the antennas that operate in the same frequency range are analysed and categorised into similar groups. The next step is to examine the design document to see whether or not there are any anti-interference safeguards included in it. In the event that there exist anti-interference measures, the application of such anti-interference measures shall be investigated. If no anti-interference measures are applied or if the measures do not apply, the compatibility of this set of antennas will be included as the risk item for review and will take its place at the top of the list. Finally, in the internal interference test of vehicles, the effectiveness of anti-same-frequency interference measures of wireless equipment is checked by working simultaneously with pairs of antennas and monitoring the functional performance of wireless equipment of the test subjects; the antenna that is listed as a risk is the one that is focused on.

ENGINEERING APPLICATION CASES:

This study presents the use of electromagnetic compatibility assessment of vehicle antennas by picking four vehicle-mounted antennas as typical representations in order to use a subway construction project as the technical backdrop for the discussion. Respectively chosen vehicle antenna for wireless communication scheduling system cluster (Tetra) antenna, the entertainment system (Infotainment) (chime feel) antenna, Door control system and the WIFI antenna, the antenna of cluster and WIFI antenna installation at the top of the cab, entertainment system antenna and antenna installed on the driver Door control console and intersection area under the windshield edge position, the relative positions of the antenna and the wireless communication scheduling system cluster (Tetra) antenna installation at the top of the cab, In the illustration, the two rectangles each represent the electromagnetic interference receiver of the signal generator, the six lines each represent one of the six cables, and the pairwise pairs of solid, dotted, and dotted lines each represent the connection of one pair of antennas when the isolation degree is being measured.

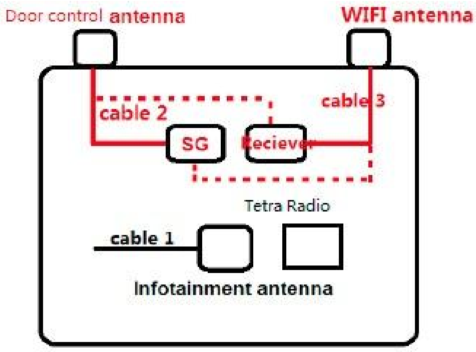

Fig.1: Location diagram of the antennas

The essential details of the antenna that is installed on the vehicle. Out of the four antennas that were tested, it is clear that the antenna for the WiFi network and the antenna for the gate control system operate in the same frequency range. Following the completion of the spectrum planning inspection procedure, it was discovered that these two antennas are capable of functioning properly at the same time without causing any electromagnetic interference to one another.

The judgement of how well the energies line up will be examined. First, a listing is provided for both the in-band and out-band transmitting power of each antenna, as well as the in-band and out-band sensitivity limitations. Then, in the process of testing cable, each one at a time for measuring the distance that separates antennas to determine the degree of isolation has been considered. the live-fire cable and cable loss difference, as well as the two collocation space isolation degrees of test coverage, are as follows: one is a kind of transmitting antenna out-of-band emission that falls within the receiving antenna belt; the other is a transmitting antenna in-band launch that falls outside the receiving antenna belt. The test results are shown in. The operating frequency interval between the cluster antenna and the entertainment antenna is rather far off from each other. For this reason, the cluster antenna is mounted on the top of the vehicle, while the entertainment antenna is positioned in the room where the driver sits. Both of them have successfully completed the spectrum planning inspection project, which indicates that the circumstances between them are superior in terms of frequency domain and space isolation. Therefore, it is not essential to analyse the in-band and out-band energy matching of the two at this time since it has already been done.

CONCLUSION:

The vehicle body floor serves as the separating line between the two groups of urban rail transit vehicle antennas. This allows the antennas to be split into two distinct categories. The operating frequency band of antennas placed on the vehicle body floor is less than 30MHz, whereas the working frequency band of antennas put on the vehicle body ceiling is more than 30MHz. It is quite unlikely that there will be any interference caused by the two different sets of antennas.

An electromagnetic compatibility assessment technique of vehicle-mounted antenna is presented, using a subway car as an example of engineering. The evaluation method that was presented in this paper compensates for the lack of directly evaluating vehicle electromagnetic compatibility based on the EN 50121 standard test method without covering the antenna port. This method has been successfully applied to multiple types of urban rail transit vehicles. The electromagnetic compatibility level of the cars that were supplied was successfully maintained thanks to the fact that all of the vehicles that were put through the EMC type test passed with flying colours.

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