The Impact Analysis of the Electromagnetic Radiation from the Ultra-High-Voltage Transmission Devices on the Automobile Experimental Base

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Abstract. Through the measuring of the electric field, magnetic field intensity induced by ultra -high voltage power grid equipment, the paper aims to study the impact of these on the basic performance of the test vehicles, the physical health of the personnel and the communication reliability of intelligent network connection as well as to evaluate whether the electromagnetic environment of the experimental base reaches the automotive test standards. At the same time, it concluded the basic measurement and evaluation methods of electromagnetic environment in automobile test base.

1. Background

With the rapid development of science and technology, a large number of electrical and electronic equipment is widely used in automotive engineering. Generally, electromagnetic environment of electronic equipment is relatively complex and various electromagnetic disturbance is likely to interfere with the operation of electronic equipment. There is a strong electromagnetic disturbance in automobile test base, which will not only influence the performance of automobile with high degree of electrification, but also lead to abnormal operation of test equipment. All of these will cause the lower accuracy of the test data and the unreliability of the evaluation results. At the same time, the strong electromagnetic disturbance will also have a negative impact on communication and personnel health. Therefore, in the construction of automobile test base, it is very important to test the electromagnetic environment. In the surrounding of one still constructing base, there are many electronic equipment like 500 KV substation, ultrahigh voltage test base and converter station. In order to study the influence of electromagnetic environment in the surrounding of the test base, this paper measured and analyzed the electromagnetic environment of the typical position around the base and made a judgment on whether the radiation field intensity under each frequency band is in accordance with the provisions of the state's safety standards, whether it has a potential influence on the vehicle test and intelligent network communication. Current vehicle electromagnetic harassment [1] sources are roughly divided into three types: vehicle on board disturbance source, natural disturbance source and artificial disturbance source. The electromagnetic disturbance tested in this paper is the third type of disturbance source.

2. Generated mechanism of Electromagnetic field

According to the theory of electromagnetic fields, there is an electric field around an electric charge or a charged conductor, and there is a magnetic field around a moving electric charge or a conductor with

current. Therefore, there is electric field and magnetic field around the power transmission facilities with electricity or in operation. The transmission of electric energy will be accompanied with the electric field and magnetic field inevitably [2]. When the frequency is low, the electric field and magnetic field are independent and have no connection to each other. The changing electric field and the magnetic field can be converted into each other and there is a quantitative wave impedance relationship between each other when the frequency is high. And the electromagnetic energy can be separated with charge and current and transmitted to the space in the form of waves. So the electric field and the magnetic field are interdependent and interconverted in the high frequency. In this way, the electric field and magnetic field collectively referred to the electromagnetic field. Under such circumstance, the electric field and magnetic field are generally referred as electromagnetic field. And this kind of electromagnetic field, which is capable of propagating electromagnetic energy to the space in the form of waves free from charge or current, is also vividly called an electromagnetic wave. In this paper, it aims to measure and analyze the impact of the electric and magnetic fields generated by the power transmission equipment around the test base.

3. Selection of the test site

The measurement sites are mainly along the boundary of the test base and the key sites is closest to the location of high-pressure facilities so as to cover the entire area as much as possible. The specific locations are shown in Figure 1.

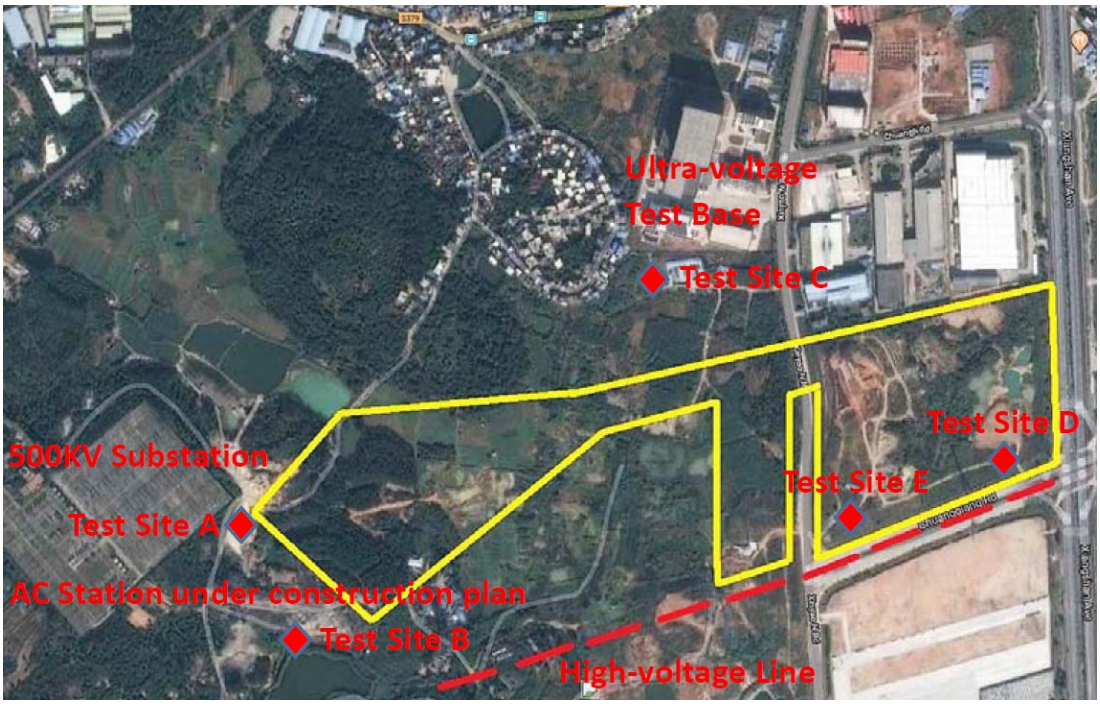

Figure 1. Test location

Where: Site A- closest location to 500KV substation in the base
Site B- closest location to 800KV DC Station (construction in plan) in the base
Site C- around one electricity grid high voltage equipment test base
Site D and E-closest location to the high voltage line in the planning laboratory area
Alternating current station- around the converter station of one electricity grid ultra-high voltage company. It is predicted that the electromagnetic environment is similar after the construction of Alternating current station in the site B.

4. Measurement and evaluation

4.1. Influence of electromagnetic environment on the test vehicles

The radio waves emitted by vehicle radio equipment, electrical equipment will interfere with the facilities on the vehicle, which will make the electronic control units out of control. Therefore, it needs to evaluate whether the high-voltage power grid near the base will influence the basic properties of the vehicle, mainly study the influence on the instrument, sensor, engine ECU, controller and other components. According to the frequency range of the existing vehicle EMC test, the frequency range of this measurement is set from 9kHz to 6GHz, and the equipment used is TS-EMF testing system and supporting software, as shown in figure 2.

Figure 2. TS-EMF Testing System

The field intensity test results within the frequency range from 9kHz to 300MHz is shown in Figure 3. It can be analyzed that the results in site A, B, E, are generally high. In the frequency band of 0.5MHz, the field intensity is prominent. Referring to the limit value in the GB/T 18655 'The limits and measurements of the radio harassment characteristics of vehicles, ships and internal combustion engines for the protection of vehicular receivers', it should be less than 52dBμV/m, namely about 0.000398V/m.

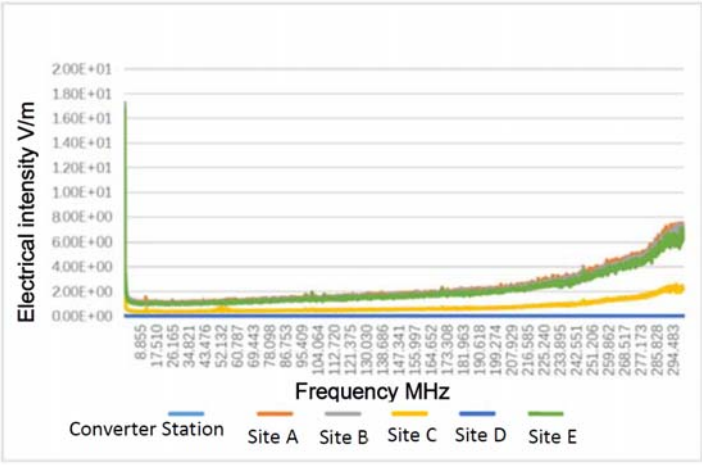

Figure 3. Field intensity test results within the frequency range from 9kHz to 300MHz on each test site

The following test data results on Table 1 show the general electrical field intensity is less than 8V/m. According to the existing vehicle and component test statistic result, this will not interfere with the vehicle normal driving, but it will affect the vehicle AM receiver.

Table 1. Field intensity test result on each test site

Test Site	Field Intensity	Exceed Multiple
Converter Station	0.00863	22
Site A	3.8	9548
Site B	4.108	10322
Site C	1.258	3161
Site D	0.00829	21
Site E	3.368	8462

The field intensity results within the frequency range from 300MHz to 3GHz are shown in Figure 4. Test Site B is closer to the base station, which cause the high field intensity of the frequency point corresponding to the 2G/3G/4G cell phone signal and the highest frequency point is in the vicinity of 2126MHz, up to 16V/m. According to GB 8702-2014 'limit Value of electromagnetic environment', the limit value should be 12V/m at this frequency, so the 16V/m field intensity of the mobile phone base station t at Site B is more than the limit value in national standard requirements. In the vicinity of 1500MHz, the frequency of intelligent network satellite navigation, each test site has no obvious interference signal. According to the ECE R10 standard, statistical data accumulated in vehicle disturbance rejection test, under the 30V/m field intensity, some vehicles will appear the abnormal phenomenon including the abnormal instrument, engine stall, motor controller failure, etc. According to the statistics of vehicle electronic components disturbance rejection test, all the tested parts can work normally below the 10V/m field intensity.

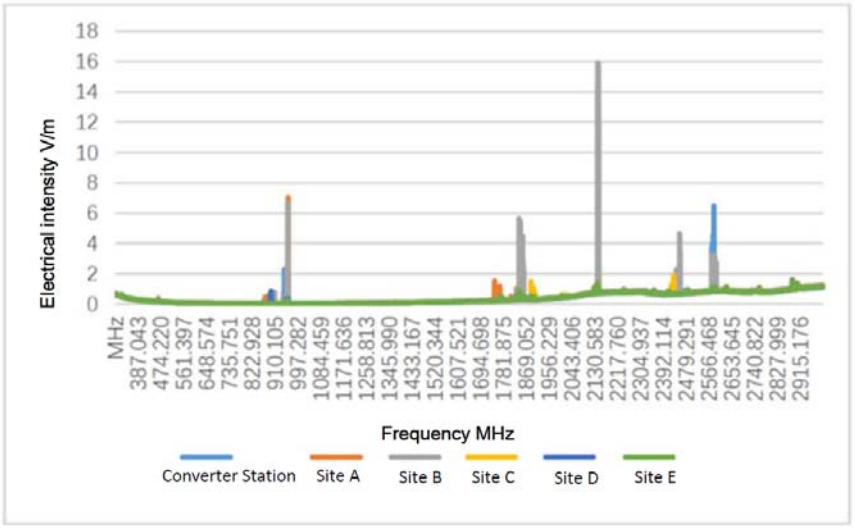

Figure 4. Field intensity test results within the frequency range from 300MHz to 3GHz on each test site

The field intensity test results under frequency range from 3GHz to 6GHz are shown in Figure 5. It shows that there is an obvious signal near the frequency of 5.8GHz in the test site D. But besides D, there is no obvious disturbance signals among the LTE-V frequency range from 5905MHz to 5925MHz which the future networking automobiles normally use.

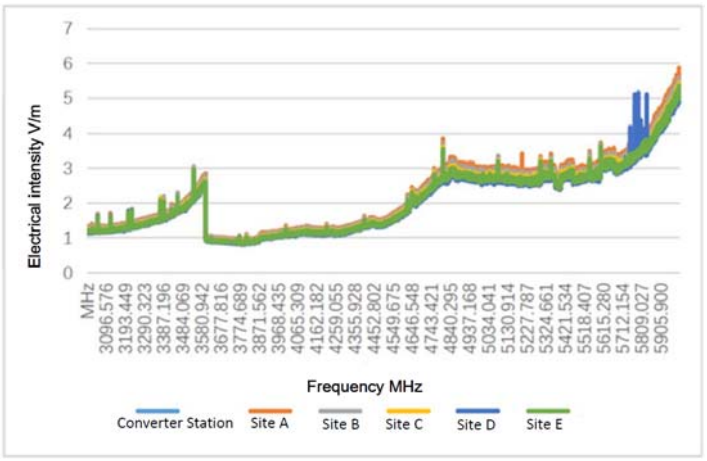

Figure 5. Field intensity test results within the frequency range from 3GHz to 6GHz on each test site

4.2. Impact of electromagnetic environment on personnel's health

With the growing improvement of people's living standard, they are increasing concerned about whether the electromagnetic environment people exposed to will bring bad effects on the health and daily life. Muscle, blood and bones in our body constitute a machine with certain conductivity, capacitance rate like battery. And the human body cell membrane itself has 75 mV endogenous electrostatic potential, and the density of endogenous current in human body is about 10mA/m². With such conditions, it's enough for coupling with the outside electric field and coupling with the ecology within the impact scope of the electricity transmission electromagnetic field within the scope of its impact on the ecological coupling, performance of which is in energy conversion, but weak coupling, limited energy conversion. At the same time, when air humidity is bigger, higher electric field intensity on the surface of the high voltage transmission lines make the air breakdown and the breakdown current heats the air, causing air vibration, noise and bringing bad impact to the human hearing[3]. ICNIRP (International Committee of Non-ionizing Radio Protection) recommends that the allowed exposure limit value (electric field intensity 5KV/m, magnetic induction intensity 100μT) in public living environment and the exposure limit value (10kV/m, 500μT) in a controlled environment which will be used to be a reference for evaluating the impact of electromagnetic environment on human health in test base. The frequency range of electric field and magnetic field measured in this paper is 1Hz to 400kHz, fully covering the power grid work frequency 50Hz and its harmonics, and the equipment used is Narda EHP-50F, as shown in figure 6.

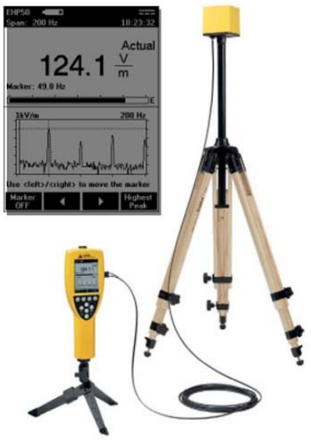

Figure 6. Narda EHP-50F

The measured results are shown in Figure 7. The electric field and magnetic field radiation level at E point is the highest, and the electric field radiation is about 23% of the international standard limit, and the magnetic field is about 3.16% of the limit value. Results of ach test point does not exceed the limit of human electromagnetic exposure value.

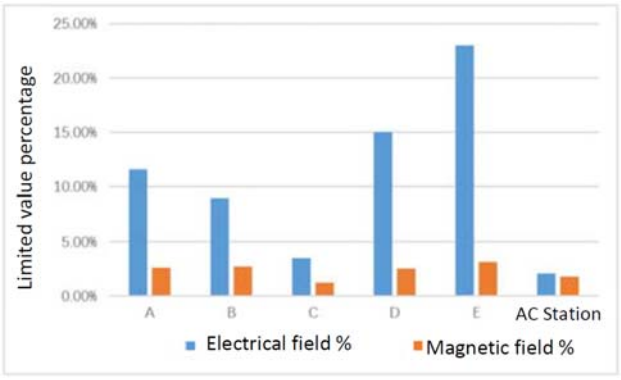

Figure 7. Radiation level of electrical and magnetic field

Field intensity comparison between each test site and one base built and used for years have been completed at 50 Hz, the results is shown in figure 8. Because the high-pressure equipment and line in this test base is high and far, so the electrical field intensity at 50 Hz is less than the maximum test result in Site A more than 60%, and maximum exposure limits at 50 Hz for body electric field is 5000 V/m, so the test sites above all meet the requirement of standard, and have no effect to human body health.

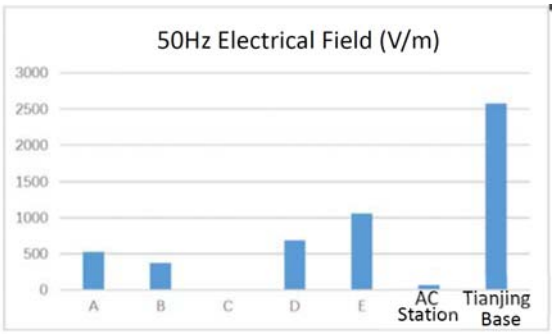

Figure 8. 50Hz Electrical Intensity Comparison

4.3. Influence of electromagnetic environment on intelligent networking communication

Currently, the intelligent networking applied in automobiles is more and more popular. Many of the control unit in vehicles are rely on the on-board network to realize communication. Once the communication signals are disturbed, it will not only affect the safety of the vehicle, but also affect the vehicle's performance and user experience resulting in inaccurate and non-objective measurement data of the vehicle. Through the collection and analysis of electromagnetic environment including satellite navigation, WIFI, mobile communications, as well as the future LTE-V frequency band in test site, it can assess the impact on the reliability of communication, especially inspect whether there is a potential interference source to affect the 5.9 GHz spectrum communication which used by future intelligent networking automobiles [4]. The measurement frequency bands in this test cover the existing GPS (1567 MHz to 1583 MHz), the Bei Dou navigation (1553 MHz to 1569 MHz), WIFI,

mobile communications, as well as the future LTE-V. The equipment used is the IQR series recorder and spectrum analysis equipment, as shown in figure 9.

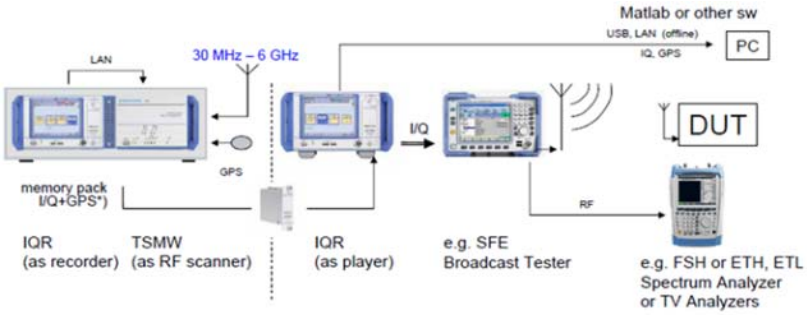

Figure 9. IQR series recorder and spectrum analysis equipment

The preliminary spectrum analysis results are as follows:

1) The 1553MHz-1583MHz frequency band, used in the GPS of intelligent network automobiles and Bei Dou satellite navigation, has no obvious interference signal at each point

2) Currently, at 2G\3G \4G frequency band used in vehicular mobile communication, network signal strength is normal at each test point, and communication equipment can work normally

3) At the frequency band of 5905MHz-5925MHz, used in the LTE-V communication of the connected vehicles, except the test point D which has wireless communication signal near the 5.8GHz, the other test points have no obvious interference signal.

Through the analysis and playback of the electromagnetic environment data collected in the field, the influence of the electromagnetic environment on the intelligent network communication (packet loss rate, error code, etc.) can be analyzed in the dark room subsequently.

5. Conclusion

The electromagnetic disturbance from ultra-voltage electric grid system on the environment concentrates in the low frequency, especially at the 50 Hz low frequency electric field. It's up to nearly 1000 times more than local environment and at 0.5 MHz, results at each test point are all greater than the limit value for protect the vehicular receiver required in the GB/T 18655-2010 'The limits and measurements of the radio harassment characteristics of vehicles, ships and internal combustion engines for the protection of vehicular receivers', which can impact the vehicular receiver AM band. In addition to test point D, which has an obvious signal at the 5.8G Hz, and there is no obvious other signal interference in the 5905MHz-5925MHz range used in the LTE-V of future connected vehicles. The electromagnetic exposure limit value of reserved field meets the standard requirements, which can be regarded as the no effect on human body. In the whole 9 KHz to 6 GHz frequency range, electric field intensity is all on the high side, so the use of precision instruments under this environment (especially high sensitivity instruments like the preamplifier, measuring receivers) have the risk of overload.

The construction of the vehicle test site needs to fully evaluate the potential impact of the electromagnetic environment from the surrounded power transformation equipment. Selected test frequency band should fully cover the frequency of automobile use and test and the test range should cover the whole test sites and the relevant national automotive electromagnetic compatibility standards, public living environment exposure limits and communication reliability requirements all should be referred to evaluate the electric field, magnetic field intensity measurement results.

References

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