Electromagnetic Compatibility Analysis in Radio Communication

Ziyan Jiang
School of Information Science and Engineering, Southeast University, Jiangsu 211189, China
364035931@qq.com

Abstract

Nowadays, radio communication is frequently used as a communication mode, but there are a lot of factors influencing spatial transmission of electromagnetic wave and thereby reducing communication quality. In order to ensure good communication quality, technicians adopt electromagnetic compatibility analysis method. On this basis, this paper firstly gives an introduction of radio frequency division, and probes into electromagnetic compatibility control technology in radio communication with an analysis of its specific application.

Keywords

Radio communication; Electromagnetic compatibility analysis Application.

1. Introduction

At the present stage, the mode used in telecommunication is radio communication, which is of fast speed. However, radio communication is susceptible to surrounding environment: the quality of radio communication is influenced by various factors and operation of radio communication equipment is hampered, and even the communication is disrupted. Considering such problems, technicians have done a lot of researches and attempts and during this process, the concept of electromagnetic compatibility is brought up. Under the impact of electromagnetic compatibility, technicians finally succeeds in reducing influence of factors, enhancing operation efficiency of equipment and improving quality of radio communication.

2. Division of Radio Frequency Band

Radio wave was found by Henry Hazlitt in 1888 and applied in communication for the first time, at which time, science of radio communication technology was formed. Afterwards, more and more scientists have continuously devoted to studying radio communication technology, they not only enriched and maturated radio communication theories but also boosted rapid development of radio communication technology. Over a hundred years, researchers have extended scope of radio communication frequency at both ends and increased width of the brand used. Thus, communication mode gradually become digitized, which enriched the types of radio communication business [1]. According to range of wave length, radio frequency spectrum is divided into 14 types, as shown in Table1. As the wave length decreases continuously, the frequency increases gradually and transmission characteristics of radio wave are changed.

According to wave theory, the wavelength is extremely larger than the dimension of the obstacle, diffraction of the wave is strengthened, when the wavelength decreases, its diffraction weakens; when the wavelength is equal to or smaller than the dimension of the obstacle, the wave is blocked by the obstacle and form shadow effect, which would hamper the propagation.

Table 1 Bands Divided by Radio-Frequency Spectrum

Band Frequency No.	Name of Band	Range of Band	Wave Length
-1	Extremely low frequency	0.03-0.3Hz	1000-1000Mm

0	Extremely low frequency	0.3-3Hz	1000-100Mm
1	Super-low frequency	3-30Hz	100-10Mm
2	Super-low frequency	30-300Hz	10-1Mm
3	Ultra-low frequency	300-3000Hz	1000-100Km
4	Very low frequency	3-30kHz	100-10Km
5	Low frequency	30-300kHz	10-1Km
6	Medium frequency	300-3000kHz	1000-100m
7	High frequency	3-30MHz	100-10m
8	Very high frequency	30-300MHz	10-1m
9	Ultra-high frequency	300-3000MHz	10-1dm
10	Ultra-high frequency	3-30GHz	10-1cm
11	Super-high frequency	30-300GHz	10-1mm
12	Extremely high frequency	300-3000GHz	10-1dmm

3. Electromagnetic Compatibility Control Technologies in Radio Communication

Electromagnetic compatibility analysis is an indispensable work in radio communication operation and management aiming at ensuring reasonable planning of radio communication through certain calculation. And electromagnetic compatibility control technologies play a crucial role in electromagnetic compatibility analysis, with which, it is possible to analyze the accurate interference problems existing in radio communication. At the present, electromagnetic compatibility control technologies mainly include five types shown as follows:

3.1 Filter technology

With filter technology, it is not only possible to cut off radio communication path and prevent signal disturbance, but also to inhibit conduction in radio communication. Therefore, it plays an important role in helping analysis of radio signal transmission state [2].

3.2 Grounding technology

In radio communication, electromagnetic compatibility analysis would influence its grounding to a certain extent. With grounding technology, it is possible to analyze whether there is interference in grounding, and to ensure that the analysis is carried out according to electromagnetic compatibility.

3.3 Shielding technology

As to electromagnetic compatibility control, shielding technology is usually adopted together with grounding technology as a combination. According to radio electromagnetic compatibility analysis results, a shielding layer in communication process is firstly designed, and then, based on characteristics of shielding materials, the specific materials to be used are selected, which are used for protection for radio communication [3].

3.4 Isolation technology

Earth loop interference is a hidden problem in radio communication, and if not effectively controlled, it would cause serious impact on quality of the radio communication and hamper operation security of the communication equipment once the interference occurs. With the isolation technology, we can realize effective control over such problem from happening and reduce its occurrence rate so as to ensure smooth operation of radio communication.

3.5 Balanced transmission technology

After application of balanced transmission technology in radio communication, balance of transmission of communication signals is improved. At the same time, with the aid of isolation technology, the earth loop interference would occur. Thus, reliability of electromagnetic compatibility control is enhanced and practicability of electromagnetic compatibility analysis is reflected.

4. Application of Electromagnetic Compatibility Analysis in Radio Communication

When it comes to radio communication, adjacent-channel interference, intermodulation interference, and co-channel interference are commonly seen problems. With the application of electromagnetic compatibility analysis, we can calculate the safe distance between frequency bands and design calculation of interference limit values, thus, we can ensure smooth transmission of radio signals and improve communication quality.

4.1 Adjacent-channel interference

The so-called adjacent-frequency interference means a receiver receives the signal from its adjacent channel and arouses interference. There are two factors causing adjacent-channel interference, first, near-far effect, and variation of relevant device parameters [4]. In the analog modulation system, bandwidth of the modulation baseband signals directly influences the bandwidth of the amplitude modulation signals: when the former signal is in double bandwidth, the latter signal is double-sideband; when the former band is in single bandwidth, the latter signal is single-side-band. And the modulation band frequency and modulation index decides the angle modulation. On the basis of Bessel family of functions, it is shown by the amplitude, if FM modulation m increases, the energy distribution width, modulation band frequency and line spacing increase. Please refer to Table 2 for details.

Table 2. Amplitude Values when FM Modulation m=1, 2, 3

FM Modulation m	1	2	3
Amplitude Value	0.785	0.594	0.497

In the digital modulation system, control signal bandwidth is also the emphasis of the adjacent-channel interference. Symbol rate, sending filter and frequency deviation are the factors affecting signal bandwidth in the system. QPSK adjacent-channel interference simulation test, the carrier is set at 2, 000 kHz, and the test is started after establishment of the system chart (as shown in Fig. 1). The received signal is set at 2, 000 kHz provided with 5 carrier frequencies for the adjacent-channel interference signal, namely: 2.08 kHz, 2.12 kHz, 2.16 kHz, 2.2 kHz and 2.4 kHz. After the test is over, the corresponding curve is prepared according to the test results. It is indicated through analysis, in radio communication, interference would occur when the adjacent-channel signal receiver and transmitter are too close. After electromagnetic compatibility analysis, the selectivity of receiver is increased to improve channel stability and effectively control adjacent-channel interference.

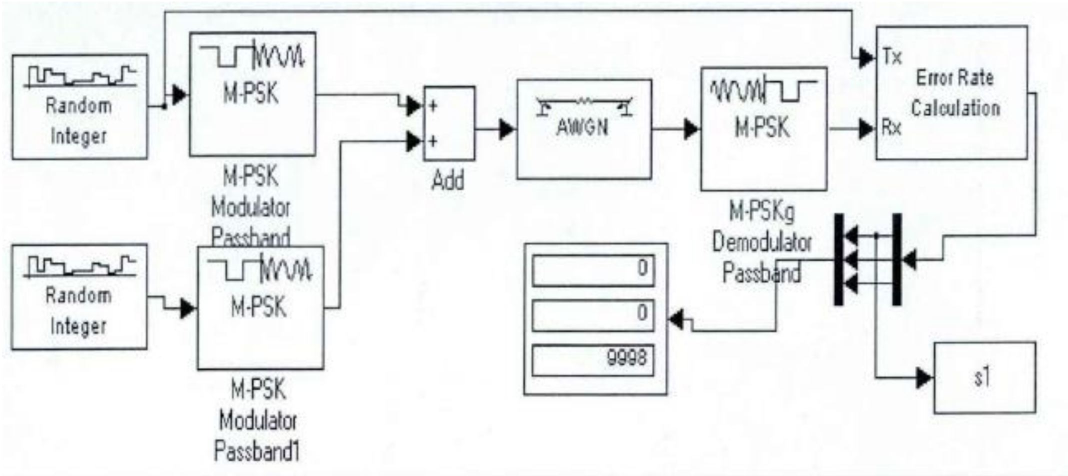

Fig. 1 QPSK Simulation System Framework

4.2 Intermodulation interference

Intermodulation interference refers to occurrence of a new frequency caused by intermodulation between several signals in the communication equipment that should not receive modulation. Besides, the new frequency would jam useful signals. Intermodulation interference can be divided into two types: first, transmitter intermodulation interference, in this case, a receiver receives signals from many transmitters, those signals are in intermodulation with each other and form a new combined frequency, which is not needed and eventually interference occurs. Second, receiver intermodulation interference, in this case, a receiver receives various strong signals. Under influence of non-linear circuits, intermodulation among signals give rise to new frequency and cause interference to the medium frequency band [5]. In order to solve the problem of intermodulation interference, it is quite necessary to eliminate one of the signals.

With the example of third-order intermodulation interference between two signals, the simulation framework is prepared after establishment of the simulation system. In this diagram, the working frequency of the system is set at 10 kHZ, and the two signals are provided with frequency of 2 and 4kHz. For 4 KhZ signal, there are 3 and 5 harmonic waves, which means the signal also includes 12 and 20kHz. With non-linear device, the sum frequency and difference frequency are obtained by multiplying 2 kHz and the 3 frequencies. It is shown by the simulation spectrum diagram of third-order intermodulation interference between two signals (refer to Fig. 2), the spectrum line is seen at six frequencies and intermodulation interference is caused due to the component produced. The frequency and corresponding Fe value are listed in Table 3. In the case of intermodulation interference, by electromagnetic compatibility analysis, we can find out relevant information and increase the distance between channels, and set the coupling loss at several transmitters, control the frequency and eliminate one of the signals so as to avoid interference.

4.3 Co-channel interference

The so-called co-channel interference refers to the interference caused by coincidence of the normal signal frequency and the frequency occupied by the interference source. During short-wave radio wave propagation, attenuation is sure to occur when the distance is over a certain value. Broadband F3E, G3E and A3E are all commonly seen signals with different radio frequency shield, as shown in Table 4. Therefore, it is necessary to take the concept of radio frequency shield into consideration in planning public communication network frequency. With regards to solving same-frequency interference problems by electromagnetic compatibility analysis, corresponding calculation is needed for reasonable planning of the communication network frequency resources. Under the situation where needs of the service area are met, it is not necessary to build a high transmission antenna with a large transmitting power.

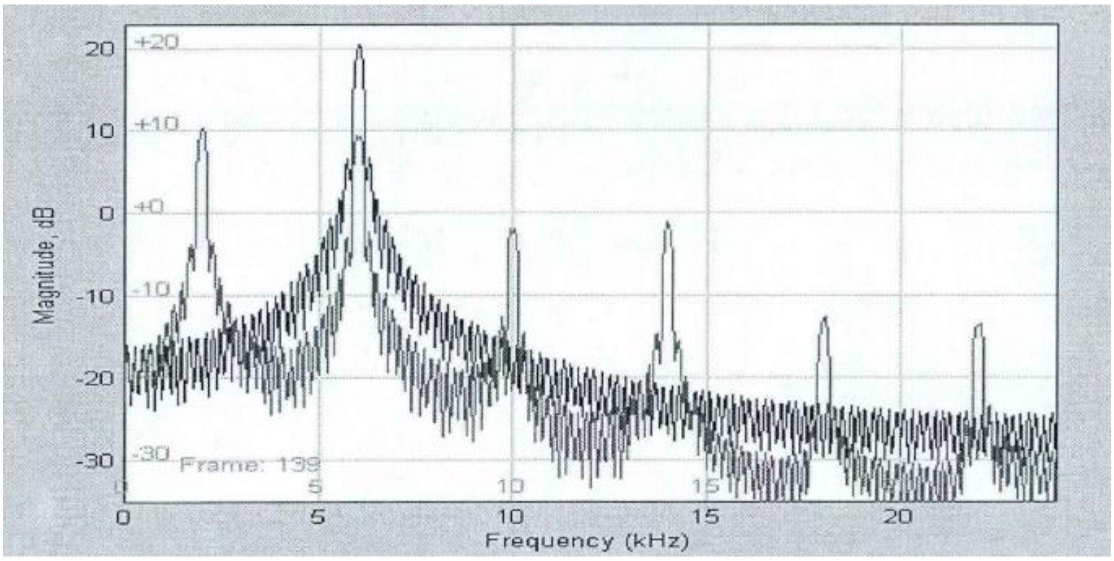

Fig. 2 Simulation Spectrum Diagram of Third-order Intermodulation Interference between Two Signals

Table 3. Third-order Intermodulation Interference Frequency between Two Signals and Corresponding Fe Value

Frequency (kHz)	4	12	20	2	6	10
Fe Value	4000	12000	20000	2000	6000	10000

Table 4. Radio Frequency Shield of Common Signal

Common Signal	Types of Interference Signal	Radio Frequency Shield (DB)
Broadband F3E, G3E	Broadband F3E, G3E and A3E	8
Narrow-band F3E, G3	Narrow-band F3E, G3 and A3E	8−10
A3E	Narrow-band F3E, G3 Narrow-band G3E and A3E	8−17

5. Conclusion

For radio communication, with the use of electromagnetic compatibility analysis, we can find out hidden interfering factors and take corresponding measures to improve communication quality.

References

[1] Zhao W S, Yin W Y, Guo Y X. Electromagnetic Compatibility-Oriented Study on Through Silicon Single-Walled Carbon Nanotube Bundle Via (TS-SWCNTBV) Arrays[J]. IEEE Transactions on Electromagnetic Compatibility, 2012, 54(54):149-157.

[2] Baldwin T E, Capraro G T. Intrasystem Electromagnetic Compatibility Program (IEMCAP)[J]. IEEE Transactions on Electromagnetic Compatibility, 1980, EMC-22(4):224-228.

[3] Manzi G, Feliziani M, Beeckman P A, et al. Coexistence Between Ultra-Wideband Radio and Narrow-Band Wireless LAN Communication Systems—Part I: Modeling and Measurement of UWB Radio Signals in Frequency and Time [J].Electromagnetic Compatibility IEEE Transactions on, 2009, 51(2):372-381.

[4] Darney I. Circuit modelling for electromagnetic compatibility[J]. Electronics & Communication Engineering Journal, 1997, 9(4):184-192.

[5] Dorić V. Electromagnetic compatibility analysis of the broadband power line communications system based on the antenna theory[J]. Hrvatska znanstvena bibliografija i MZOS-Svibor, 2009:134.