

PAPER • OPEN ACCESS

Study on Radiation Characteristics of Electromagnetic Equipment

To cite this article: Yamin Sun *et al* 2019 *J. Phys.: Conf. Ser.* **1237** 042073

View the [article online](#) for updates and enhancements.



IOP | ebooks™

Bringing you innovative digital publishing with leading voices to create your essential collection of books in STEM research.

Start exploring the collection - download the first chapter of every title for free.

Study on Radiation Characteristics of Electromagnetic Equipment

Yamin Sun, Zhiyong Yu, Chen Pang

Rocket Force University of Engineering, Xi'an 710025, China

Corresponding author's e-mail: 1348395737@qq.com

Abstract. Aiming at the increasingly complex battlefield electromagnetic environment, the basic composition of natural radiation source and artificial electromagnetic radiation is analyzed. In order to construct and simulate complex electromagnetic environment, a general electromagnetic equipment radiation source modeling method is proposed, which is various on the battlefield. Electronic countermeasures equipment can be described by five components to describe the characteristics of its frequency domain, energy domain, and signal modulation domain.

1. Introduction

Informatized weapons and equipment have been widely used on the battlefield. A large number of electromagnetic radiators are deployed in a limited area of the battlefield, a limited frequency domain, and a limited time domain. The fierce confrontation between the enemy and the enemy's electronic warfare equipment has formed a complex, dense and dynamic battlefield electromagnetic environment. The contradiction between weapon and battlefield electromagnetic compatibility is prominent, and the difficulty of electromagnetic spectrum control is increased, which seriously affects and restricts battlefield perception, command and control, precision strike, weapon and equipment performance and force generation. The battlefield electromagnetic environment is an electromagnetic environment that affects operations in a certain battlefield space. It consists mainly of military electromagnetic activities, including natural electromagnetic radiation and electromagnetic radiation generated by military and civilian electronic equipment. The sum of various electromagnetic phenomena that affect combat operations. The electromagnetic environment of the battlefield mainly affects the performance of information equipment, which in turn affects operational operations.[1-2]

Any device that produces electromagnetic radiation or electromagnetic leakage is a source of electromagnetic radiation.[3] There are many kinds of electromagnetic equipment on the battlefield, and various forms, such as radar, communication, electronic countermeasures, navigation and other artificial electromagnetic radiation sources, regardless of the enemy or our side, formed a radar electromagnetic environment, communication electromagnetic environment and etc. The environment, in addition to the natural electromagnetic environment such as electromagnetic pulse, lightning, etc., these environments overlap, will have a complex impact on equipment. How to accurately describe and model a variety of electromagnetic radiation sources is a difficult problem involving many different disciplines and fields.

2. Electromagnetic equipment radiation source and its characteristics

The electromagnetic environment radiation source refers to the source device or system that radiates electromagnetic waves to the outside, and is the most important material basis for the formation of complex electromagnetic environment phenomena. Electromagnetic equipment radiation source is the



root of the complex battlefield electromagnetic environment. It can be said that without the radiation source, there is no electromagnetic environment.

2.1 Electromagnetic equipment radiation source classification

The electromagnetic radiation sources involved in the complex electromagnetic environment are various in variety and characteristics. From different research perspectives, there are many types of electromagnetic equipment radiation sources.

- According to the frequency band in which the radiation source works, it can be classified into a microwave radiation source, a low frequency radiation source, an intermediate frequency radiation source, and the like;
- According to the usefulness of the received information, it can be divided into signal radiation source and noise radiation source;
- Classification by presence or absence of excitation sources can be divided into passive radiation sources and active radiation sources;
- Classified according to the cause of the radiation source, it can be divided into natural radiation sources and artificial radiation sources.

2.2 Natural radiation source

Natural sources of radiation include: cosmic rays, static electricity, and lightning radiation.

Literature [4] proposes that cosmic rays are high-energy particle streams emitted from space, consisting of primary cosmic rays and secondary cosmic rays. It is believed that cosmic rays are high-energy particle radiation from the universe, which is mainly composed of some protons, alpha particles and a core with an atomic number $Z > 3$. Due to the shielding effect of the atmosphere, the total amount of cosmic radiation reaching the Earth's surface is greatly reduced. In the literature, it is only a qualitative description. There is no quantitative calculation of the radiation frequency and radiation power of cosmic rays. The literature [1] [2] pointed out that static electricity is a physical phenomenon in which the positive and negative charges on the surface of the object are separated. There are four factors that determine how much static electricity is generated: the material and purity of the material, the environmental conditions, the shape parameters of the material, and the frequency of friction. Lightning is also an electrostatic discharge phenomenon. A large amount of electric charge is accumulated in the thunderstorm cloud. The electric field strength between different parts of the cloud increases continuously, increasing beyond the insulation level of the air (10^4V/cm), and the air will be hit, resulting in lightning phenomenon. The same is just a qualitative description, there is no quantitative calculation.

Under normal circumstances, electrostatic electrification and discharge occur simultaneously, and the rising edge of electrostatic discharge is short, which is sub-millisecond.

As shown in Figure 1, the simulated electrostatic discharge can generate a pulse with a peak value of 10Kv, a rising edge interval of less than 1 ns, and a delay of 200 ns.

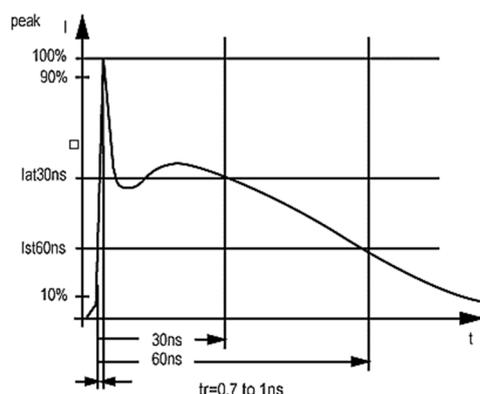


Figure 1 Current waveform of electrostatic discharge

2.3 Artificial radiation source

The artificial electromagnetic radiation mainly includes pulse discharge, microwave, radio frequency electromagnetic radiation, etc., and the artificial radiation source includes civil electronic equipment, electronic information equipment, high-altitude nuclear electromagnetic pulse, high-power microwave and the like.

Civil electronic equipment refers to civil electronic facilities approved by the national spectrum management department, mainly including radio stations, wireless televisions and some civilian stations. The radiation frequency and radiated power of civil radiation sources require authorization, fixed frequency and power, and fixed signal mode. Table 1 shows the frequency bands, effective radiated power, field strength range and range of action of common civil radiation sources.

Table 1 Frequency bands, effective radiated power, field strength range and working distance of common civil radiation sources

Radiation source	Frequency band (MHz)	Effective radiation power (dBW)	Field strength (V/m)	Effective distance (km)
AM broadcast	0.5~0.6	46~51	0.2~5.8	0.3~1.9
FM broadcast	88~108	88~108	2.0~8.3	50
Wireless TV	47~800	68	1.0~3.5	0.5~3.5
Low frequency communication equipment	0.01~0.5	60	0.25~2.1	5~20
Mobile communication	900~1000	17~21	0.2~1.5	0.04~0.2

Electronic information devices use electromagnetic fields as carriers to perform their functions by transmitting and receiving signals. Unlike other sources of radiation, it is both a source of electromagnetic radiation and a subject affected by a complex electromagnetic environment. Common electronic information devices include radar device radiation sources, communication system radiation sources, and the like. The radar transmits signals by using electromagnetic waves as a carrier, and receives signals for target detection. Its parameters include radar operating frequency, radiated power, polarization mode, and signal modulation mode. The main function of the communication system is to transmit information. The types of transmission media can be classified into wired communication and wireless communication. Among them, wireless communication devices have more electromagnetic radiation, so wireless communication is mainly studied. The wireless communication analog communication signal includes an amplitude modulation signal, a phase modulation signal and a frequency modulation signal; the wireless communication digital communication signal can be divided into an amplitude shift keying signal, a frequency shift keying signal, and a phase shift keying signal according to different radio frequency modulation modes.

3. Electromagnetic equipment radiation source modeling

3.1 Radiation source component modeling

In the actual battlefield, in order to construct and simulate the electromagnetic environment[5-6], it is necessary to describe all the electromagnetic radiation source devices of the enemy and the enemy in the battlefield and their working conditions, including electromagnetic effects on the electromagnetic equipment. The various enemy and enemy electromagnetic radiation source devices also include targeted communication and radar interference devices capable of generating electromagnetic threats to communications and radar equipment. We know that the types of electromagnetic equipment radiation source equipment in the battlefield environment are complicated, and it is almost impossible to construct each of the above two electromagnetic radiation source equipments separately. Therefore, this paper uses the general electromagnetic equipment radiation source modeling method to realize This purpose.

The universal equipment electromagnetic model (electromagnetic equipment radiation source) is set up in a customized manner, and it is required to be able to define various types of equipment. Therefore, the project uses a flexible assembly mode to define the equipment electromagnetic model. In general, considering the requirements of electromagnetic environment simulation and modeling, it is only necessary to describe the electromagnetic radiation characteristics of all equipment in the battlefield. In the case of considering only the electromagnetic radiation characteristics of the equipment, the receiving equipment and the receiving and electromagnetic sensitive characteristics of the equipment may not be described in the electromagnetic equipment model. In this case, the electromagnetic equipment modeling and application flow block diagram is shown in Figure 2.

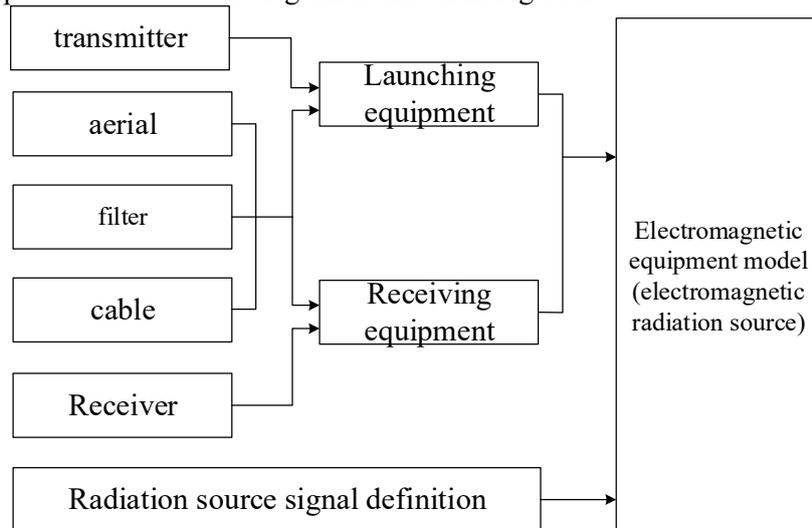


Figure 2 Electromagnetic radiation source modeling and application flow diagram

The transmitting device is composed of several types of components such as an antenna, a transmitter, a receiver, a filter, and a cable. The main description parameters of several types of components are as follows:

- Transmitter

The main parameters include: frequency, modulation type, occupied bandwidth, necessary bandwidth, emission class, frequency feature description, second-order intermodulation attenuation, third-order intermodulation attenuation, harmonic attenuation, digital modulation mode, modulation factor, data rate, and so on.

- Antenna

The main parameters include: frequency, polarization, cross-polarization isolation, maximum gain, antenna pattern description (horizontal and vertical).

- filter

The main parameters include: frequency, frequency characterization, reference frequency and so on.

- Receiver

The main parameters include: frequency, modulation type, necessary bandwidth, IF bandwidth, emission class, impedance, required signal-to-interference ratio, required signal-to-noise ratio, noise figure, sensitivity, processing gain, frequency characterization, IF attenuation, 2nd order mutual Attenuation, 3rd order intermodulation attenuation, blocking level, image frequency attenuation, local oscillator type, pulse duration (radar), number of pulses (radar), integration method (radar), digital modulation, modulation factor, data rate, Sensitivity threshold (signal-to-interference ratio), blocking interference saturation power, etc. The receiver is mainly used to describe the receiving characteristics (sensitivity characteristics) of the electromagnetic equipment, and is a model of the electromagnetic environment effect.

- RF cable

The main parameters include: frequency, frequency attenuation feature description, length, etc.

- Radiation source signal

The main parameters include: signal form, modulation mode, modulation parameters and so on.

As can be seen from the above description, whether it is communication, radar equipment or navigation, various electronic countermeasure devices can be described by the above general model. The components of the transmitter, filter, RF cable, antenna, and source signal can fully describe the characteristics of the frequency domain, energy domain, and signal modulation domain of an electromagnetic device. The component description parameters listed above are all external feature descriptions, and do not involve the internal structure and specific implementation of the device, so it can be easily obtained and modeled more conveniently. For passive radar targets, the electromagnetic model mainly describes the RCS (radar cross-sectional area) at various angles of the space.

4. Conclusion

In this paper, aiming at the description of the radiation characteristics of all electromagnetic radiation source devices in the battlefield, a five-component transmitter, filter, cable, antenna and radiation source signal are used to describe the frequency domain and energy of an electronic equipment. A method for modeling electromagnetic radiation source components that is common to the characteristics of the domain and signal modulation domain. For the passive electromagnetic radiation source in the battlefield, it is traditionally described from the description of the physical and electromagnetic characteristics of the interference, but it has certain limitations. This paper compares the interference and target characteristics from four aspects: airspace, time domain, frequency domain and energy domain, and quantifies and models the interference.

References

- [1] Wang Y Q 2006 *The electromagnetic environment of the battlefield* (Beijing: People's Liberation Army Press) pp 1-61
- [2] Li N and Zhang X F 2008 *Analysis of the complex electromagnetic environment of the battlefield* (Changchun: Equipment Environmental Engineering) pp 16-19
- [3] Guo H, Yan J H, Zhou B and Zhang S L 2011 *Electromagnetic leakage analysis of RF simulation test system* (Luoyang: Marine Electronic Engineering) pp 172-175
- [4] Pan Z Q 1986 *The principle of limiting the exposure of the public to natural radiation sources* (Beijing: Atomic Energy Press)
- [5] You J Y and Lai L J 2014 *Electronic Warfare Complex Electromagnetic Environment Simulation Technology* (Jiaying: Journal of China Academy of Electronics Science) pp 517-520
- [6] Guo S X, Dong Z Y, Meng J and Gao Y 2013 *Research on Complex Electromagnetic Environment Simulation Technology* (Xi'an: Foreign Electronic Measurement Technology) pp 21-25