

An Integrated Communication Jamming Simulation Training System

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Abstract. As the consumption of the true radio set is high and the communication interference grade is undistinguishable, a set of communication jamming simulation training system was developed in this paper. A broad-band communication module is used in this training system, and through the frequency domain equivalent mapping, the hardware-in-the-loop simulation radio equipment in different frequencies is realized. In the training system, the interference evaluation index system is built and then the quantitative evaluation methods for hardware and software damage of communication equipment generated under complex electromagnetic environment is put forward and shown in the virtual interface. The frequency spectrum monitor modular is adopted in the training system to help the trainee understand the mechanism of jamming and anti-jamming in frequency domain. Thus the developed simulation training system is integrated with the function of interference mechanism demonstration, real-time interference effect display and anti-jamming operation.

1 Introduction

Whether the communication equipment can give full play to the combat effectiveness or not depends on the level of army mastering the equipment. Under the condition of complex electromagnetic environment, it is the urgent problem of the college education and military training carrying out the training of communication equipment, and acquainting the trainees with the impact of electromagnetic interference on communication equipment, improving the protection consciousness, and having the ability to take the right counter measures and tactics. There are three problems need to be solved about communication jamming training. Firstly, the battlefield electromagnetic environment simulation, Secondly, how to select the trained communication equipment, as using the practical radio equipment to train is expensive, large quantity required and easy to damage. Thirdly, how to visualize the communication jamming and anti-jamming effect, as the display interfaces of most communications equipment are very simple, and the disturbance phenomenon of different grades can not be directly distinguished.

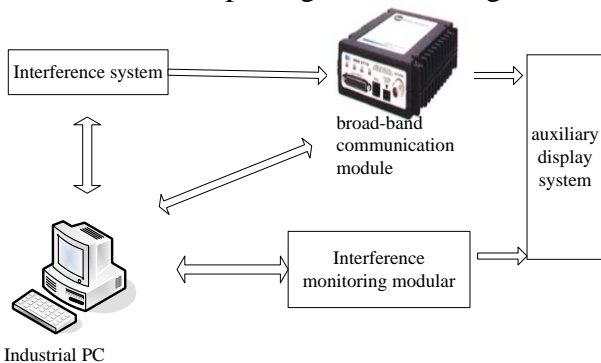
Simulation training system, which has been widely used in forces, has advantages of low-risk, good-secrecy and easy automation^{[1][2]}. In article [3], an airborne communications training simulation system is developed, In article [4], a communication jamming simulation training system is designed and realized, and the system can create electromagnetic circumstance under tactics background and evaluate the operation performance. In article [2] a kind of comprehensive simulated system which is applied to the communication of the station is designed. Aimed to the jamming effectiveness evaluation and the interference grade demarcation, in article [5] the information flow and the power rule are used, and the relationship between the phonetic syllable and the ratio of interference to signal is also analyzed. In article [6] the jamming effect evaluation system based on semantic message is designed. However, these methods are only designed for software fault but not take into account the hardware damage. In this paper, a hardware-in-the-loop simulation of radio function about a military shortwave radio and an ultra short wave radio are realized using the virtual instrument technology. For the communication jamming effect evaluation, a communication jamming effect evaluation

system is designed in terms of the temperature of the internal device, bit error rate, voltage, signal spectrum and signal-to-noise ratio and other indexes.

2 The composition and the function of communication jamming simulation training system

The purpose of communication jamming training is to let the trainee clearly understand the interference mechanism, directly cognitive the interference effect, and master the anti-interference operation of the radio equipment. Therefore, based on simulating the regular operation and the anti jamming operation, the principle demonstration and the interference quantitative evaluation are designed in the developed training system. That can make the trainee understand the principle of jamming and anti-jamming know the operation and have the ability to confront. By spectrum monitoring directly display the process of communication disturbance and mechanism. The interference evaluation index display is added on the basis of original radio communication interface, and can present the performance of the internal changes of communication equipment, and display real-time interference effect of different grade. Through simulating the anti-interference function of the radio and spectrum monitoring, the anti-jamming principle is illustrated and the operation training is implemented.

After determining the radio station model, we analyze the technical parameters of the radio performance, and finally choose an available digital radio data transmission or communication transceiver module as the core. The virtual radio interface is developed on the industrial PC through LabVIEW, and the radio station model is realistic simulated. And successively solve the problem of equivalent interference signal generation and interference effect of visualization. After components assembly, the hardware platform of the system is structured. The communication jamming simulation training system is integrated by the virtual communication transmitter-receiver, the equivalent communication jamming equipment communication interference visualization system. The concept map is shown in figure 1. Where the software part about the virtual communication station and the interference visualization system are realized on the industrial PC, and the modular hardware and industrial PC are packaged in the designed case. The appearance design is shown in figure 2.



Industrial PC

Fig.1 the main structure of the Communication Jamming Simulation Training System



Fig.2 The appearance of the virtual communication equipment

3 the virtual communication station

The virtual communication station is implemented by the integration of software and hardware. The main function of communications is accomplished by a communication module. The virtual radio communication interface and the control of the communication module are developed on the industrial PC by LabVIEW. With a shortwave radio station as an example, the virtual communication station is implemented through the following three steps.

3.1 One to one correspondence of the radio lights and the keyboard commands

The radio work types are divided into five modes such as remote control, fixed frequency, adaptive, frequency hopping and compatible. Among those modes, the radio is not controlled by the panel in the "remote control" mode. The "Compatible" mode mainly designed to communicate with other

system of frequency hopping radio communication. The radio light is only considered on the three kinds of working condition of “fixed frequency”, “adaptive” and “frequency hopping”.

The response relationships of the station in the five kinds of mode between each button and indicator light are simulated in the program for one to one correspondence, and the virtual radio is realized. Take the frequency hopping pattern for example, in this mode, the main key and system work flow is shown in figure 3.

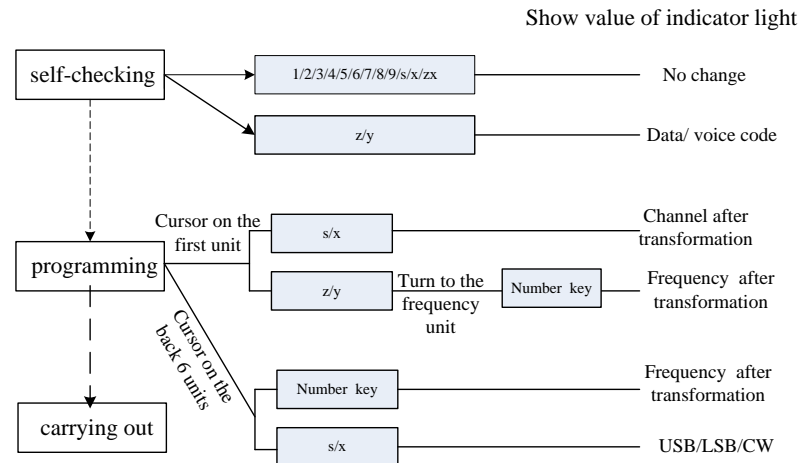


Fig.3 the corresponding relationship between the main keys and the workflow in the fixed Frequency pattern
3.2 control of the Hardware module

The communication function of the virtual communication radio is achieved by the communication module, and through changing of frequency/channel on the virtual interface to correspond to the communication module. At the same time, to show the system state, the parameters such as temperature, voltage are displayed by controlling serial port of the communication module. Hardware control is mainly implemented by controlling some serial ports. The serial port commands of the communication module are listed as shown in table 1.

3.3 The realization of the commonly used anti-jamming measures of the communication equipment

The methods and measures of the communication anti-jamming technology can be divided into four kinds. Firstly, the anti-interference technology in frequency domain priority with spread spectrum technology. Such as direct sequence spread spectrum (DS-SS), frequency hopping (FH), DS/FH hybrid spread spectrum technology, adaptive frequency selection technology, adaptive frequency domain filtering technology. Secondly, the time-domain anti-interference techniques, such as adaptive time-varying and processing technology; Burst communication; Low speed communication technology; Jump (TH) technology; Adaptive signal power management techniques. Thirdly, the anti-interference techniques in airspace by adapting nulling antenna. Fourthly, the error correction coding technology.

The anti-interference technology is realized mainly by controlling the serial port command of the communication module and making an equivalent mapping between parameters associated with the virtual radio. Using the wideband communication module and the frequency domain equivalent mapping, the fixed frequency and the frequency hopping pattern of the ultra short wave radio or the shortwave radio can be simulate on hardware. Using the same set of framework and public communication jamming evaluation library, on the software the self-adaptive match between different equipment interface and background control logic can be realized. The extensibility of developed training system is large.

Table 1 the list of serial port command

command name	function
CKEY[ON-OFF]	CKEY command support or not support continuous firing patterns of the radio. When CKEY set to ON, continuous launch
CTS[0-255]	CTS (allow - send) command select or display the timer values related to the CTS line response. The command parameter range is from 0 to 255 milliseconds.
SER	display the radio serial number

DKEY	this is to use the KEY command to make the transmitter not emission after the emission of transmitter
DLINK[ON/OFF/XXXX]	This command is used to configure the network used in the diagnosis of local diagnostic communication protocol.
DUMP	With only this command can reveal all programming set value.
INIT	Used for the operational parameters of the radio again initialized to factory default values.
KEY	Starting the command transmitter, see DKEY command
MODEM[xxxx, NONE]	This command to select radio modems.
PWR[20-37]	In order to read the actual (measured) radio power output, use the SHOW PWRS command.
RSSI	display continuous station received signal strength indicator (RSSI), in dBm.
RX[xxx. xxxx]	Select or display radio receive frequency in units of MHz. Usually 6.25 kHz is the frequency step size.
TX[XXX.XXX]	Select or display the transmitting frequency of the radio in MHz
UNIT[10000..65000]	Sets or displays radio unit address
TEMP	show the internal temperature of the radio in °C
SHOW[DC,PORT, PWR]	show the dc voltage, diagnostic port and transmitted power level

4 interference effect evaluation

4.1 coupling mechanism of the communication interference

The electromagnetic pulse coupling into the communication equipment is mainly in the two ways of "front door" and "back door"[2]. In many cases, the coupling from the "back door" is the main cause of the system being disturbed. Casing hole seam is often the main way of the coupling, Those hole seams do good shielding effect to the low frequency electromagnetic pulse, but it is easy for high frequency pulse energy coupling into the equipment through the hole slot. The coupled radio pulse voltage superimposed on the original signal circuit, as if the signal reaches a certain level, it will lead to the change of the output logic value, that is to turn "1" into "0" or on the contrary. That will result in IC chip operation errors, changing the logic level of the digital circuit and computer, program chaos, data read/write error, perform a jump, work interruption and other disturbing phenomenon, those are the soft faults. If the coupling voltage or current up to a certain extent, hard damage will happen. It will make the voltage, current or power seriously exceed what the electronic components can bear so as to result in the breakdown or damage of some components or integrated circuit. That finally leads to the perpetual damage of devices.

4.2 jamming effect evaluation method

The electromagnetic interference can not only result in speech distortion, dropped calls, digital communication and other software errors, but also cause hardware damage to its internal electronic devices. However, the existing communication jamming evaluation focuses on software damage, such as the bit error rate, speech intelligibility, signal to noise ratio and other indexes used for jamming effectiveness evaluation and relevant test methods. In this paper, the theory analysis of electromagnetic environment effect, ADS simulation calculation and live-fire experiment are used to construct the comprehensive evaluation index system with internal temperature, voltage, bit error rate, signal-to-noise ratio and system fault state as the core of communication interference damage, and the equivalent extrapolation model the frequency domain and the interference of power domain are used to provide the quantitative evaluation method about the hard and soft damage of the selected short and ultra short wave radio.

Table 2 jamming grades and damage phenomenon

Jamming grades	Damage phenomenon	evaluation index
First Grade	Electronic components appear larger than an information processing cycle pause, work is not stable.	Soft damage indexes: Bit error rate, signal-to-noise ratio, signal power, etc. Hardware damage indexes: system failure state, internal temperature, voltage, etc.
Second grade	A system of communication electronic components temporary blindness caused by equipment temporarily, lose its function.	
Third grade	Completely destroy the electronic components of communication system, equipped with a complete failure.	

Usually the digital signal transmission quality is measured by bit error rate. It is generally believed that when the error rate is 2%, the communication information are not reliable, in order to obtain reliable information transmission, information need to repeat. When the interference error rate reduced to 50%, digital information is completely disrupted, it is unable to transmit information, and the interference completely suppressed the communication signal. Usually once the digital signal bit error rate achieves 20%, normal communication can't sustain, and it is considered that the interference effectively suppress the target signal.

The essence of voice communication jamming effectiveness evaluation is the voice quality evaluation. The objective evaluation of the voice quality is rapidly developed since the 1970s, researchers have proposed many objective evaluation parameters. According to the main technology and domain, these parameters are divided into spectrum parameters, LPC (Linear Prediction code) parameters, auditory model parameters, etc. However, the method of sound quality subjective evaluation is fit for the quality evaluation of communication system but not for the communication jamming effectiveness evaluation, for instances, MOS, its value is concentrate below score 2 as the voice distortion is serious.

Thus, we select the signal to noise ratio, bit error rate and the power of the interference signal to measure the interference effect.

5 Conclusion

Communication interference simulation training system is mainly aimed at the problem that the communication interference is not intuitive and the consumption of practical equipment training is big. the virtual instrument technology is used to develop the hardware-in-the-loop simulation of military radio station, the multi-sensor technology and general speed measuring software technology are used to real-time monitor damage indexes, such as temperature of the hardware-in-the-loop radio components, voltage, bit error rate, signal to noise ratio, etc. accordingly, the problem of radio communication hardware and software damage evaluation and visualization under the condition of electromagnetic interference is solved. In addition, the system platform achieves the functions of effectiveness mechanism demonstration, interference effect display, anti-jamming operations training. It provides an effective means training for the interference of communication equipment.

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