Generation of radio pseudo-target signals to evaluate some functions of electronic warfare complexes on ships

Pham Van Hoa[1*], Dang Viet Hung[1], Nguyen Nam Truong[2], Tran Hoai Nam[3]

[1]Institute of Electronics, Academy of Military Science and Technology;
[2]Naval Region 2, Vietnamese People's Navy;
[3]Naval Region 4, Vietnamese People's Navy;
*Corresponding author: phamhoa.vdt@gmail.com
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ABSTRACT

Nowadays, generating radio target signals for electronic warfare complexes on ships is a necessity, it allows to support of research and mastery, repair and restoration, manufacture of replacement materials, and regular technical test for the complexes at the ship's units. This paper presents some research results in building a solution for generating radio target signals for electronic warfare complexes on ships. The radio target signals with remotely configurable parameters (including carrier frequency, pulse width, pulse repetition frequency, and pulse beam width) are generated and transmitted to the receiving antenna of the reconnaissance and jamming equipment; thereby, we perform tests and evaluate some functions of the complex. The generated radio signal parameters are measured and evaluated in the laboratory to achieve the specifications and meet the actual requirements.

Keywords: Electronic warfare; Navy ships; Super high frequency; Generating radio signals; Functional evaluation.

1. INTRODUCTION

In high-tech war, electronic warfare (EW) plays an increasingly important role. The EW complexes on ships have the following functions: Radio reconnaissance, early detection, analysis, classification of targets and their carriers according to danger levels; Jamming by active pulse noise to reconnaissance radars, weapon control radars, radio homing of anti-ship missiles, etc. of an enemy in order to protect its ship [1-3]. The training of surveyors, technical tests, and guarantee for the EW complexes on ships always need active radio transmission targets from the outside with variable parameters to suit the complex [2].

Up to now, domestic studies related to the EW complexes on ships have mainly focused on mastering, restoring and repairing, and manufacturing replacement materials [1, 3]. Therefore, it is necessary to study, design, and manufacture a remote radio signal generator (RSG) system to evaluate the reconnaissance and jamming functions of the EW complexes on ships. This paper presents some results of the research, building a system model and solutions for generating radio target signals for the EW complexes on ships. After that, the system is designed, manufactured, measured, and evaluated the main technical parameters of the system in the laboratory.

2. A SOLUTION FOR IMITATING THE RADIO TARGET SIGNALS

2.1. Requirements for radio signal generation systems

The main targets of the EW complexes on ships are reconnaissance radars, fire control radars, and radio homing of anti-ship missiles. Based on studying a number of targets used in NATO and Chinese Army, and the features of the EW complexes on

ships in Vietnam [1-5], an RSG system is designed and manufactured to meet the following requirements: It generates radio target signals for the EW complexes on ships with remotely configurable parameters, including Carrier frequency in (8 - 18) GHz, pulse width in (0,1 - 150) μs, pulse repetition frequency in (0,2 - 5) kHz, pulse beam width in (1 - 100) ms. The output power of the device is (1 - 3) W.

2.2. Building a model of a radio signal generator system

In order to meet the above requirements, a model of the RSG system to evaluate the reconnaissance and jamming functions for the EW complexes on ships was built in figure 1.

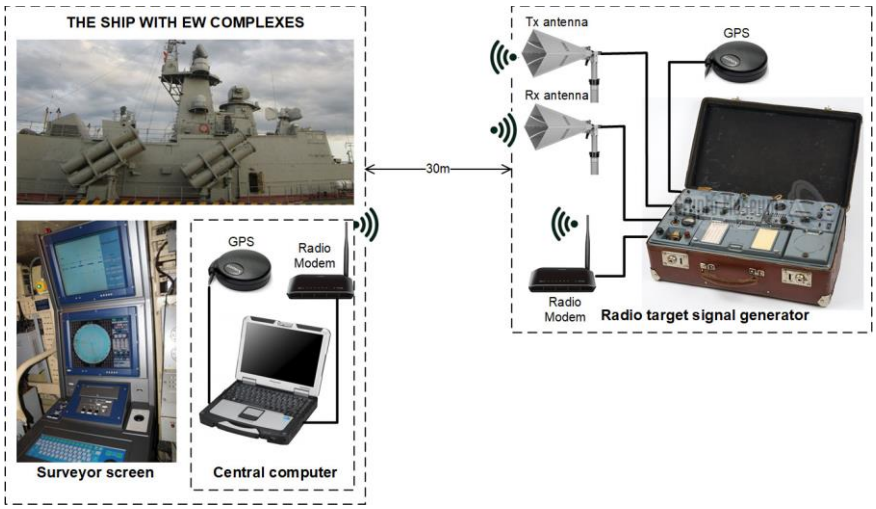

Figure 1. *The model of the remote RSG system for the EW complexes on ships.*

The system consists of two parts:

1) A central computer device (CCD) is placed on the ship, next to the screen of the EW surveyor, to perform the following tasks: It remotely controls and sets the operating parameters of the RSG device via a radio channel, including Carrier frequency, pulse width (PW), pulse repetition frequency (PRF), pulse beam width (PBW); Controls and displays parameters to support the evaluation of some reconnaissance and jamming functions for the EW complex.

2) A RSG device is located around the ship with the EW complex, which has the following functions: It generates and transmits radio signals for the EW complex on the ship at a distance of ≤ 30 m from the receiving antenna of the complex; Receives and processes the jamming signal from the EW complex on ships, then sends its parameters to the outputs.

Based on the mentioned requirements and tasks, the functional diagram of the RSG device is designed in figure 2. The parameters of the generated radio signal are fed to the FPGA module via the DATA IN line. The SHF signal is generated by two PLLs with VCOs, divided into two bands: X (8 - 12 GHz) and Ku (12 - 18 GHz). An algorithm to control the RSG is shown in figure 3. The FPGA module will control the corresponding PLL to lock the VCO at a set frequency in the range (8 - 18) GHz, and this generates a continuous SHF signal. The step attenuation (ATT) is also controlled by the FPGA to equalize the output powers over the whole frequency range.

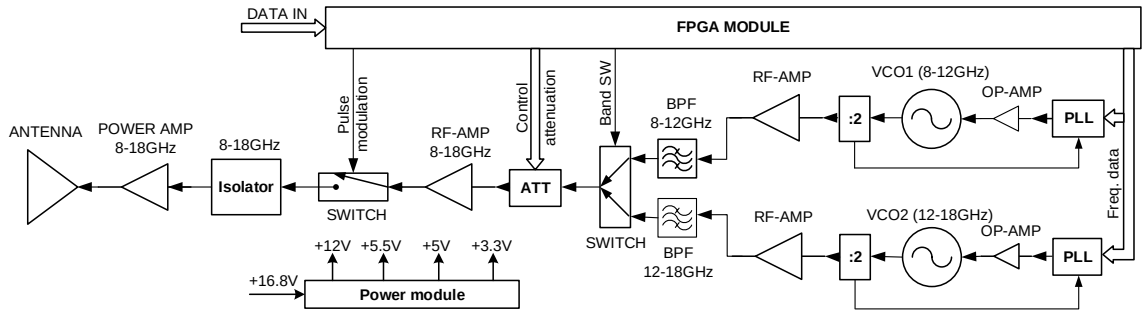

Figure 2. *Functional diagram of the RSG equipment.*

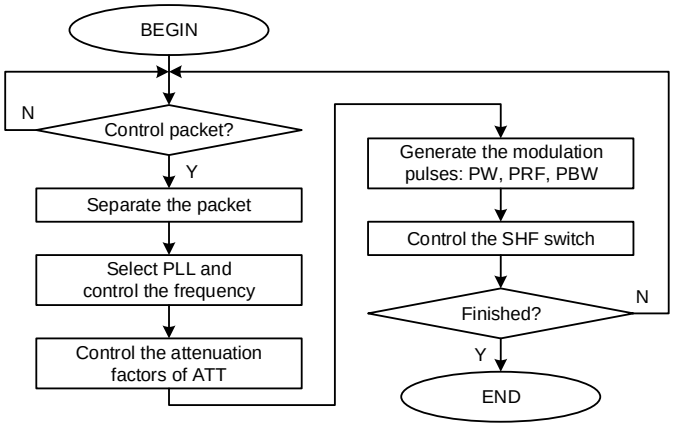

Figure 3. *The algorithm flowchart to control the radio signal generator.*

Pulse parameters (PW, PRF, PBW) are generated by modulation pulses from the FPGA module to control the SHF switch. Thus, its output will have an SHF pulse signal according to the set parameters. The RSG device uses a wide-band 3 W power amplifier, an isolator module will isolate the high-power signal and the rear modules.

3. EXPERIENCE MEASUREMENT AND EVALUATION OF THE SYSTEM

With the designed and manufactured system, we can experimentally measure and evaluate in the laboratory. The RSG device was set to the following parameters: Carrier frequency in (8 - 18) GHz, PW in (0,1 - 150) μs, PRF in (0,2 - 5) KHz, PBW in (1 - 100) ms. Its output SHF power was measured by a Real-Time Spectrum Analyzer, and the transmitted pulse signal was measured by an Oscilloscope. Table 1 shows the output power levels at different frequencies with PW of 1 μs, PRF of 1 kHz, and PBW of 30 ms.

Table 1. *Output power levels of the RSG device at different frequencies.*

f (GHz)	8,0	9,0	10,0	11,0	12,0	13,0	14,0	15,0	16,0	17,0	18,0
P_{out} (dBm)	33,7	33,5	34,5	34,6	34,8	34,3	33,1	33,5	34,2	34,2	33,7

The chart of the output power levels of the RSG device by frequency is shown in figure 4. Thus, the following observations can be drawn:

- The output power is relatively uniform over the entire frequency range, with flatness ≤ 0,9 dB;

- The maximum power reaches 34.8 dBm (approximately 3.0 W) at 12 GHz, and the smallest power is 33.1 dBm (approximately 2.0 W) at 14 GHz.

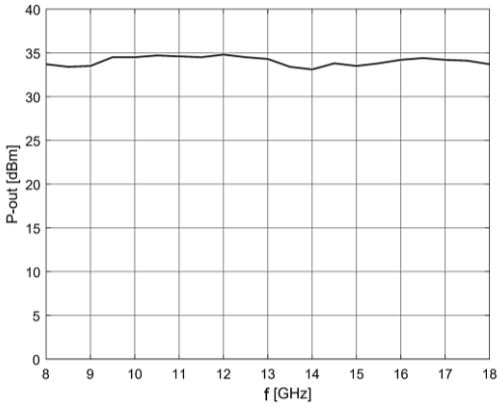

Figure 4. *The chart of the output power levels of the RSG device by frequency.*

From the test results, it can be seen that the RSG device has fully met the main requirements and specifications, and can be used to test and evaluate some radio reconnaissance and jamming functions for the EW complexes on ships.

4. CONCLUSIONS

With the proposed solution, the RSG system for the EW complexes on ships has been designed and manufactured based on available materials and components on the market with a compact structure and maneuverability, its specifications satisfy the basic requirements, supports for the research on mastering, overall evaluation of the complex after repaired, restored, replaced materials and regular technical test for the EW complexes on ships. The RSG system can be used for research units or ship units equipped with the EW complexes. The research results are the basis for continuing to research and manufacture RSG systems with an extended frequency range and a higher transmitted power. After trying it out, it is possible to improve other technical-tactical features or develop in the direction of manufacturing new active pulse jamming devices on ships and on land.

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TÓM TẮT

Giải pháp tạo giả tín hiệu mục tiêu vô tuyến điện nhằm kiểm tra một số chức năng của tổ hợp tác chiến điện tử trên tàu

Tạo giả tín hiệu mục tiêu vô tuyến điện cho các tổ hợp tác chiến điện tử trên tàu là nhu cầu cần thiết hiện nay, cho phép hỗ trợ công tác nghiên cứu làm chủ, sửa chữa khôi phục, chế tạo vật tư thay thế và kiểm tra kỹ thuật thường xuyên tại các đơn vị tàu. Bài báo trình bày một số kết quả trong nghiên cứu xây dựng giải pháp tạo giả tín hiệu mục tiêu vô tuyến điện cho tổ hợp tác chiến điện tử trên. Tín hiệu mục tiêu vô tuyến điện với các thông số có thể thiết lập từ xa (gồm: tần số sóng mang, độ rộng xung, tần số lặp xung, độ rộng chùm xung) được tạo ra và phát tới anten thu của thiết bị trinh sát và chế áp, từ đó thực hiện các bài kiểm tra, đánh giá một số chức năng hoạt động của tổ hợp. Các thông số tín hiệu vô tuyến tạo giả được đo đạc, đánh giá trong phòng thí nghiêm, đạt được các chỉ tiêu kỹ thuật đặt ra và đáp ứng yêu cầu thực tế.

Từ khoá: Tác chiến điện tử; Tàu hải quân; Siêu cao tần; Tạo giả tín hiệu vô tuyến; Đánh giá chức năng.