Research on 5G mobile networks in Vietnam, design selection and testing of 5G Mobile Communications Jamming Device

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***Abstract*— According to the research presented by the authors in [1], we propose research content, applying new technical technologies to research and design 5G mobile communications jamming devices. The goal of research and product design is to meet the basic requirements of technical indicators, operating features as well as specific requirements of the Public Security. In this article, the authors introduce some initial results of testing and evaluating 5G mobile communications jamming devices in frequency bands n28, n40, n41 (in which, n41 is divided into two frequency bands n41A and n41B) and n77. This not only has practical significance in scientific research and technology mastery, but also serves as a basis for the authors to continue developing products applying SDR technology to design and manufacture intelligently controlled, adaptive jamming devices in the future, meet work requirements of the Public Security, while diversifying the methods of operation for the Public Security force in practice.**

***Tóm tắt*— Theo nghiên cứu đã được các tác giả trình bày trong [1], chúng tôi đề xuất nội dung nghiên cứu, áp dụng các công nghệ kỹ thuật mới để nghiên cứu, thiết kế thiết bị gây nhiễu thông tin di động 5G. Mục tiêu nghiên cứu, thiết kế sản phẩm là đáp ứng được các yêu cầu cơ bản về chỉ tiêu kỹ thuật, tính năng hoạt động cũng như những yêu cầu riêng của ngành Công an. Trong bài viết này, nhóm tác giả giới thiệu một số kết quả ban đầu thử nghiệm đánh giá thiết bị gây nhiễu thông tin di động 5G băng tần số n28, n40, n41 (trong đó, n41 được chia hai khối băng tần số n41A và n41B) và n77. Điều này không chỉ có ý nghĩa thiết thực trong công tác nghiên cứu khoa học, làm chủ công nghệ mà còn là cơ sở để nhóm tác giả tiếp tục hướng phát triển sản phẩm ứng dụng công nghệ SDR để thiết kế, chế tạo thiết bị có điều khiển thông minh, gây nhiễu thích nghi trong tương lai, đáp ứng yêu cầu công tác của Ngành Công an, đồng thời đa dạng các phương thức hoạt động cho lực lượng Công an trong thực tiễn.**

Keywords*— *5G, n77, n78, jamming, information security, frequency band, planning, amplification, spectrum.

Từ khóa*— *5G, n77, n78, gây nhiễu, an toàn thông tin, băng tần số, quy hoạch, khuếch đại, phổ tần số.

I. 5G MOBILE NETWORK IN VIETNAM

A. 5G network infrastructure model in Vietnam

Regarding the commercial deployment of 5G, there are currently 2 5G models deployed in the world: 5G dependent on NSA (Non-Stand Alone) and 5G independent SA (Stand Alone). In which, most network operators deploy the "5G dependent" NSA model. This is a model that uses the same access network infrastructure and existing core network of the 4G network, thereby taking advantage of existing devices and coverage, helping to reduce costs and shorten deployment time, but the disadvantage is that it has not yet solved the requirement of extremely low latency and meeting the

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extremely large number of simultaneous connections in the same range [2, 3].

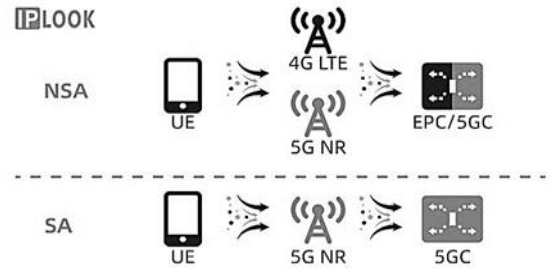


Figure 1. Operating model of 5G NSA and 5G SA networks [14]

For Vietnamese network operators, most are using 5G infrastructure that depends on 4G networks to take advantage of faster deployment and better coverage than standalone 5G networks. Currently, Vietnamese network operators mainly build 5G network infrastructure models following the 5G NSA architecture based on frequency bands planned by the Radio Frequency Department.

Figure 2. Viettel 5G Massive MIMO 8T8R and 32T32R transceiver stations (Operating frequency band 2496 – 2690 MHz (FR1-N41-3GPP))

Viettel's 5G network is being researched in the direction of combining both SA and NSA architectural models. Accordingly, SA will deploy in places where there is demand for services such as self-driving cars, IoT services, smart services, etc., to meet the needs of individualization. On Viettel's network, SA has been deployed right from the time of testing the 5G network (in Ha Nam, Hanoi, Da Nang...).

B. 5G frequency bands in Vietnam

According to 3GPP release 15, the frequency bands for 5G NR have been specified, and TS 38.104 section 5.2 provides a list of bands with which 5G NR can operate. FR1 and FR2 are the basic band classifications for 5G-NR. They can be further classified into three bands: (1) Frequency Division Duplex (FDD) Band; (2) Time Division Duplex (TDD) Band; (3) Supplementary Band: Supplementary Downlink Band (SDL) & Supplementary Uplink Band (SUL).

1. Operating frequency bands for NSA 5G mobile network terminals in Vietnam

The operating frequency bands are specified in QCVN Regulation 129: 2021/BTTTT for 5G NSA mobile network terminals operating on all or one of the combined frequency bands specified in Table 1 and complying with regulations on management and use of radio frequencies in Vietnam.

TABLE 1. 5G NSA MOBILE NETWORK TERMINALS

Combined Band Sets	**E-UTRA/ 5G**	**Bands UL**	**Bands DL**
		BS receiver / UE transmitter	**BS transmitter / UE receiver**
		$F_{UL,\ low}$ - $F_{UL,\ high}$ (MHz)	**$F_{DL,\ low}$ - $F_{DL,\ high}$ (MHz)**
DC_1_n40	1	1 920 ÷ 1 980	2 110 ÷ 2 170
	n40	2 300 ÷ 2 400	2 300 ÷ 2 400
DC_1_n41	1	1 920 ÷ 1 980	2 110 ÷ 2 170
	n41	2 496 ÷ 2 690	2 496 ÷ 2 690
DC_3_n40	3	1 710 ÷ 1 785	1 805 ÷ 1 880
	n40	2 300 ÷ 2 400	2 300 ÷ 2 400
DC_3_n41	3	1 710 ÷ 1 785	1 805 ÷ 1 880
	n41	2 496 ÷ 2 690	2 496 ÷ 2 690
DC_8_n40	8	880 ÷ 915	925 ÷ 960
	n40	2 300 ÷ 2 400	2 300 ÷ 2 400
DC_8_n41	8	880 ÷ 915	925 ÷ 960
	n41	2 496 ÷ 2 690	2 496 ÷ 2 690
DC_28_n40	28	703 ÷ 733	758 ÷ 788
	n40	2 300 ÷ 2 400	2 300 ÷ 2 400
DC_28_n41	28	703 ÷ 733	758 ÷ 788
	n41	2 496 ÷ 2 690	2 496 ÷ 2 690

2. *Operating frequency bands for 5G SA mobile communication network terminals in Vietnam*

Operating frequency bands are specified in QCVN Regulation 127:2021/BTTTT for 5G SA mobile network terminals operating overall or one of the combined frequency bands

specified in Table 2 and complying with regulations on management and use of radio frequencies in Vietnam.

TABLE 2. 5G SA MOBILE NETWORK TERMINALS

Bands 5G	Bands UL BS receiver / UE transmitter FUL, low - FUL, high (MHz)	Bands DL BS transmitter / UE receiver FDL, low - FDL, high (MHz)	Duplex Mode	Classification
n1	1920 ÷ 1980	2110 ÷ 2170	FDD	FR1
n3	1710 ÷ 1785	1805 ÷ 1880		
n5	824 – 835	869 ÷ 880		
n8	880 – 915	925 ÷ 960		
n28	703 – 733	758 ÷ 788		
n40	2300 ÷ 2400	2300 ÷ 2400	TDD	
n41	2496 ÷ 2690	2496 ÷ 2690		
n77	3300 ÷ 4200	3300 ÷ 4200		
n78	3300 ÷ 3800	3300 ÷ 3800		
n258	24250 ÷ 27500	24250 ÷ 27500	TDD	FR2

5G SA mobile communication network mobile phone devices must ensure minimum operation in all frequency bands n1, n3, n28, n41, n77, n78.

3. Operating frequency bands of 5G mobile communication base station devices in Vietnam.

The operating frequency bands and nominal output power of the base station are specified in the QCVN 128:2021/BTTTT standard for 5G mobile communication base station equipment operating on all or any of the frequency bands specified in Table 3 and Table 4.

TABLE 3. 5G BASE STATION FREQUENCY BANDS

Frequency Bands	Bands UL BS receiver / UE transmitter FUL, low - FUL, high (MHz)	Bands DL BS transmitter / UE receiver FDL, low - FDL, high (MHz)	Duplex Mode
n1	1920 ÷ 1980	2110 ÷ 2170	FDD
n3	1710 ÷ 1785	1805 ÷ 1880	FDD
n5	824 ÷ 835	869 ÷ 880	FDD
n8	880 ÷ 915	925 ÷ 960	FDD
n28	703 ÷ 733	758 ÷ 788	FDD
n40	2300 ÷ 2400	2300 ÷ 2400	TDD
n41	2500 ÷ 2690	2500 ÷ 2690	TDD
n258	24250 ÷ 27500	24250 ÷ 27500	TDD

TABLE 4. NOMINAL OUTPUT POWER OF BASE STATION

Type of Base station	Nominal output of Base station
Wide Coverage Base Station	Unlimited
Medium Coverage Base Station	≤ 38 dBm
Narrow Coverage Base Station	≤ 24 dBm

C. 5G Frequency Bands Auctioned for Commercial Use in Vietnam

The authors has updated the planned frequency bands at several locations in Hanoi, Da Nang, and Ho Chi Minh City as a basis for researching and designing 5G jamming devices.

1. n28 band (n28-700APT)

The n28-700APT band with Frequency Division Duplex (FDD) is a band released after television digitization and is considered a valuable band to meet the development needs of mobile communication in many countries including Vietnam (Figure 3).

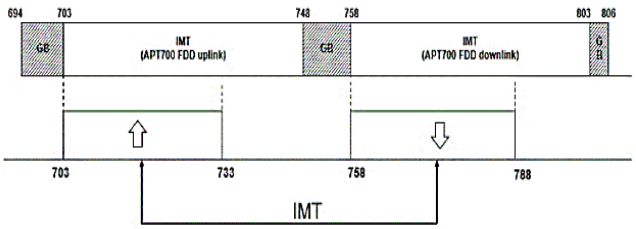


Figure 3. N28 band spectrum planning (IMT)

The band (703÷733) MHz is reserved as the uplink band, divided into 03 blocks, namely B1, B2 and B3, each block has a width of 10 MHz The band (758÷788) MHz is reserved as the downlink band, divided into 03 blocks, namely B1', B2' and B3', each block has a width of 10 MHz are divided in Figure 4.

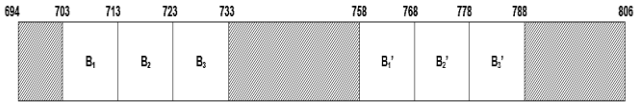


Figure 4. Spectrum division of n28 band

In the regular press conference in May 2024, The Authority of Radio Frequency Management confirmed that it will quickly auction the 700 MHz band for 4G/5G in 2024. Currently, Viettel is testing 4G/5G, the measurement results are shown in Figure 5.

2. n40 band (n40)

This band is divided into 3 time-divided duplex (TDD) blocks each with a width of 30 MHz TDD means that the same band is used for both uplink (UL) and downlink (DL) transmissions, but not at the same time. Instead, the time is divided into specific time slots or time frames for UL and DL transmission (Figure 5).

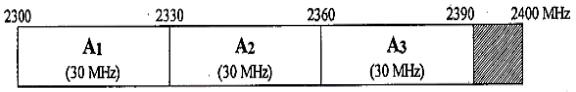


Figure 5. Spectrum division of n40 band

This band is being tested for 5G networks, in which Viettel is testing for the A3 band (Figure 5).

3. n41 band (n41)

The 2500 – 2690 MHz band is divided into 2 TDD blocks, B1 with a width of 100 MHz and B2 with a width of 90 MHz (Figure 6).

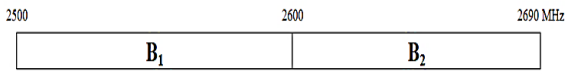


Figure 6. Spectrum division of n41 band

This band is used to test 5G, Viettel is developing 5G gNodeB in this band. On March 8, 2024, Viettel officially successfully auctioned this B1 band to deploy 5G.

4. n77/78 bands (n77, n78)

The 3600 - 3980 MHz band is divided into 04 frequency blocks according to the TDD transmission method (Figure 7).

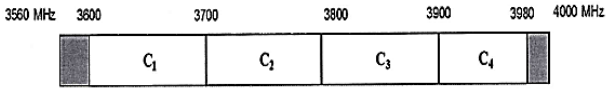


Figure 7. Spectrum division of n77/78 bands

On March 19, 2024, VNPT officially successfully auctioned the C1 block. On July 9, 2024, MobiFone successfully auctioned the C3 block of this frequency band. In addition, Viettel network also has a license to test in this frequency band.

Up to now (August 2024), three network operators, Viettel, Vinaphone and MobiFone, have successfully auctioned the 2500 MHz to 2600 MHz band, the 3700 MHz to 3800 MHz band, and the 3800 MHz to 3900 MHz band, respectively.

A. Evaluation and selection of solutions for research, design and manufacture of 5G mobile communications jamming devices

Currently, network operators are testing 5G, so the measurement locations are often not fixed, the measurement results only evaluate some key technical parameters such as coverage, bandwidth, intensity and spectrum type. At the frequency bands planned for 4G and 5G, the measurement results show that the 4G and 5G frequency spectrums are similar and the 5G bandwidth is wider, but the coverage is narrower, so the 4G jamming solution can be applied to 5G.

To meet the professional requirements in the new situation, setting the goal of researching and designing 5G mobile communications jamming devices in a proactive manner is an important task that is topical, scientifically experimental and brings high economic efficiency as well as combat effectiveness. In [1, 15], the authors mentioned some risks and solutions for 5G mobile communications jamming as follows:

- Conventional jamming.

- Spoofing jamming.

- Random jamming.

- Frequency hopping jamming

- Control channel jamming

“Currently, several more advanced jamming solutions have been published. However, upon investigation, the authors have identified two characteristics: (1) these solutions mainly improve existing solutions to enhance jamming performance; (2) some solutions remain at the theoretical research and simulation stage, but have not been applied to the actual products on the market. Therefore, the authors did not delve deeply into these, focusing instead on conventional jamming solutions that are effective. Through a survey of popular and currently used devices, the authors found that

most imported mobile communications jamming devices mainly use conventional jamming solutions [10]. The following comments can be made about the devices using conventional jamming solutions:

(1) The advantages are thorough interference in the designed frequency band, easier fabrication process, simple operation process, maintenance, maintenance and price in accordance with the conditions of Vietnam.

(2) The disadvantage of this type of devices is that the jamming frequency bands are fixed, difficult to adjust, when mobile service providers deploy on new bands, the jamming devices needs to be redesigned or additionally upgraded according to these frequency bands.

It has been evaluated that when the jammer/signal ratio reaches a certain value (with an uplink line of 5 dB), the 5G system will be disconnected and the results of the normal jamming test with a power level of 53 dBm are able to disconnect the mobile phone with a jamming distance of hundreds of meters [9, 11].

II. System analysis and design

A. Objectives and system block diagram

The research objective and design of 5G mobile communications jamming devices at frequencies < 6GHz has been proposed by the authors in [1], following the frequency spectrum planning and being tested and deployed by network operators for 5G at 758-788 MHz, 2300-2400 MHz, 2500-2600 MHz, 2600-2690 MHz, 3700-3800 MHz and 3800-3900 MHz [4-6].

As the above analysis, selecting the jamming solution in Part I, the authors performed the fabrication of conventional jamming devices. This is one of the forms of jamming attack in which the entire spectrum of the target signal is jammed by emitting a jamming signal with a larger bandwidth than the bandwidth of the mobile signal. Regarding the technique of performing 5G mobile communication jamming, it is performed by the conventional jamming method similar to the implementation of 2G, 3G, 4G network jamming, however, the bandwidth required to jam is larger, the jamming frequency is higher [7, 9, 12, 13].

B. Device Block Diagram

The 5G mobile communication jammer has 6 new frequency bands that need to be manufactured: n28, n40, n41 (divided into two frequency bands n41A and n41B) and n77 (divided into two frequency bands n77A and n77B).

The components of the 5G jammer blocks [1] are as follows.

- Low voltage power supply block.
- Oscillator block.
- Sweep voltage adjustment block.
- Voltage-controlled oscillator block.
- Buffer amplifier block.
- Power amplifier block.
- RF radiation block.

Based on the selection of jamming

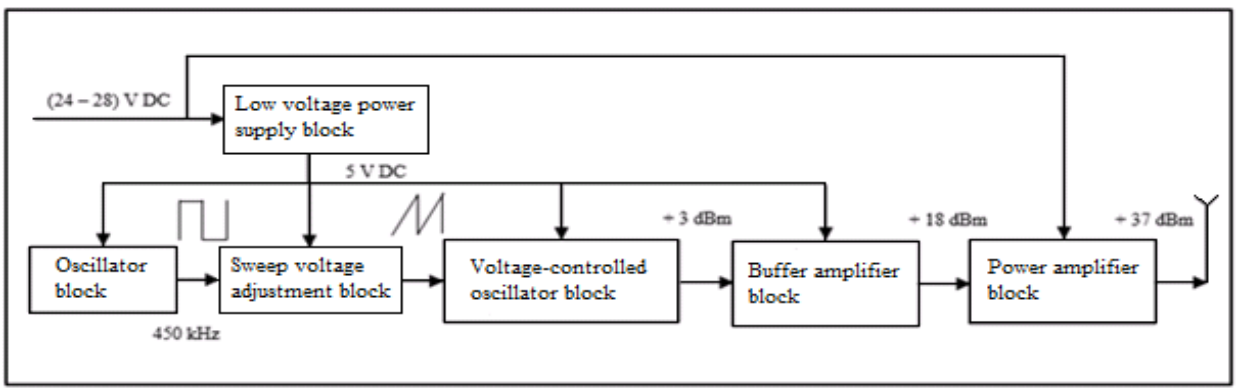


Figure 8. Block diagram of 5G mobile communications jamming device with integrated jamming of 2G, 3G, 4G frequency bands

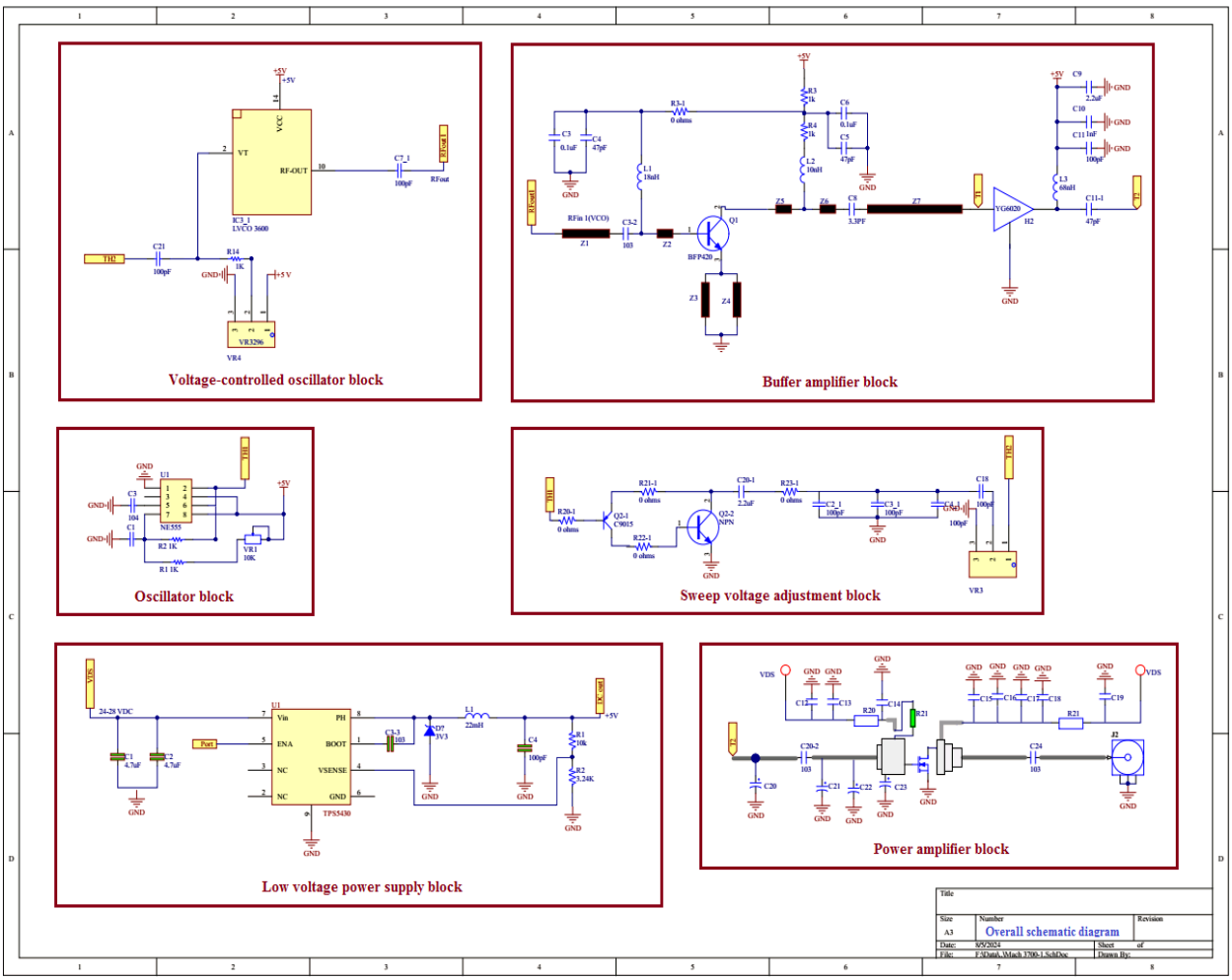


Figure 9. Circuit diagram of a single frequency band of 5G mobile communications jamming device

solutions, the authors have studied the design and built a single-band block diagram of the device (show in Figure 8) and a circuit schematic diagram (show in Figure 9).

The device operates in downlink jamming modes of the frequency bands 700 MHz and the frequency bands 2300 MHz, 2500 MHz, 2600 MHz, 3700 MHz and 3800 MHz, It is possible to choose to jam each frequency band or jam all frequency bands simultaneously. The jamming power for 5G frequency bands is 5 W, 2G, 3G, 4G is 10 W with an error of ± 10%.

III. TEST RESULTS

A. Measurement results of jamming frequency bands at the Electronics Laboratory

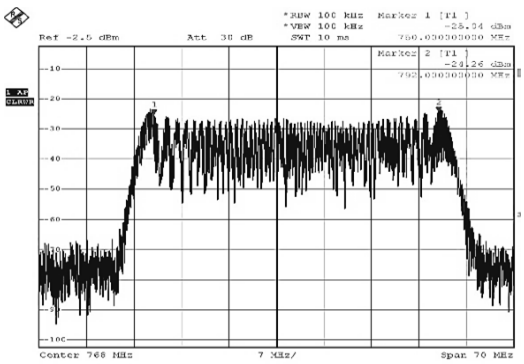
Measurements were taken at the Electronics Laboratory at 80 Tran Quoc Hoan Street, (Cau Giay District, Hanoi) with dimensions of 20 m long, 6 m wide, area of 120 m2. Equipment used for testing: R&S ESPI signal spectrum analyzer, high frequency cable, 50Ω impedance coupler (Figure 10).

Figure 10. Set up measurement configuration in the Electronics Laboratory

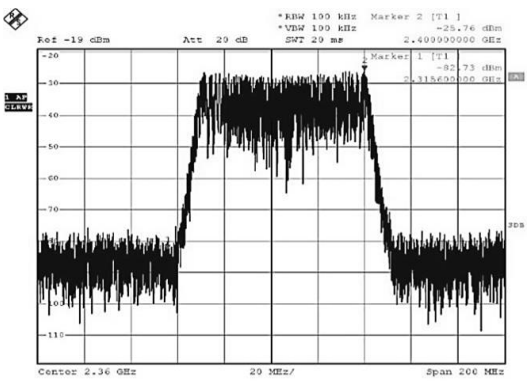
TABLE 5. MEASUREMENT RESULTS OF JAMMING FREQUENCY BANDS

Working Frequency Bands of 5G Mobile Jamming device	Frequency by Design (MHz)		Frequency by measurement results (MHz)	
	Start of the frequency band	End of the frequency band	Start of the frequency band	End of the frequency band
B28/ n28 (DL)	758	788	757,5	788,4
B40/ n40	2300	2400	2299,5	2400,2
B41/ n41	2500	2600	2499,5	2600,4
	2600	2700	2599	2700,5
n77	3700	3800	3699	3801
	3800	3900	3798,5	3901,5

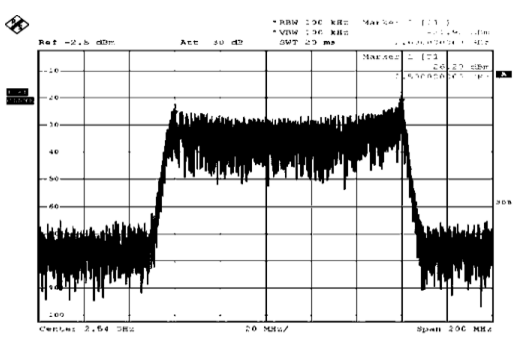
The results of frequency spectrum measurements shown on the signal analyzer are given in Table 4 and Figure 11 from 11a to 11f.



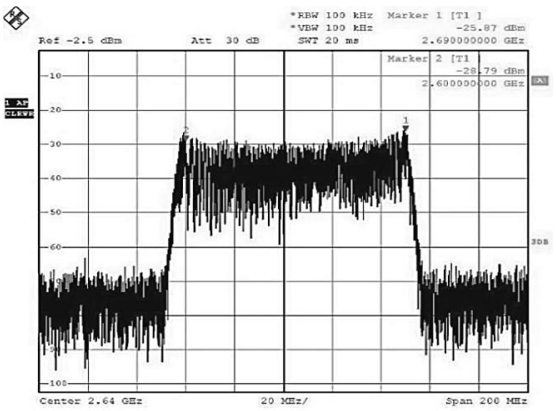
a. Jamming spectrum band 700 MHz



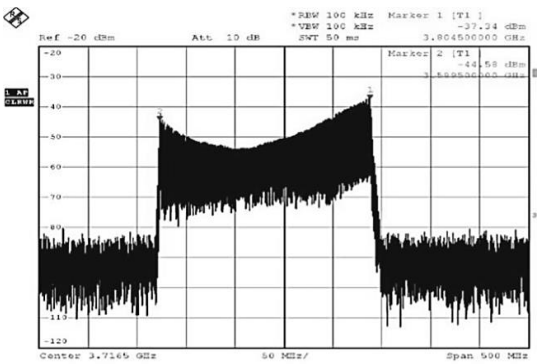
b. Jamming spectrum band 2300 MHz



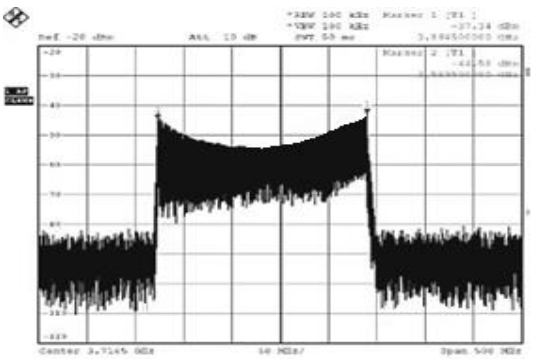
c. Jamming spectrum band băng 2500 MHz



d. Jamming spectrum band 2600 MHz



e. Jamming spectrum band 3700 MHz



f. Jamming spectrum band 3800 MHz

Figure 11. The results measured the jamming frequency spectrum of 5G Jammer on R&S ESPI signal spectrum analyzer (Including figures a, b, c, d, e, f)

B. Measurement results of jamming power on each frequency band

Equipment used for testing: 5G jammer; The E9301B power sensor (Keysight); N1913A power meter (Keysight).

Figure 12. Set up power measurement configuration in the Electronics Laboratory

TABLE 6. MEASUREMENT RESULTS OF JAMMING POWER ON EACH FREQUENCY BAND

Frequency bands (MHz)	Power (W)	
	By design	By measurement results
757 ÷ 788	5 ± 10 %	5,35
2300 ÷ 2400	5 ± 10 %	5,48
2500 ÷ 2600	5 ± 10 %	5,45
2600 ÷ 2700	5 ± 10 %	5,42
3700 ÷ 3800	5 ± 10 %	5,95
3800 ÷ 3900	5 ± 10 %	5,45

C. Practical testing in Meeting Room

Practical testing in Meeting Room at 47 Pham Van Dong Street (District Cau Giay, Hanoi) with dimensions 16 m long, 8 m wide, area 128 m2.

Equipment used for testing: Oscor green spectrum analyzer; iPhone 12 Promax (Vinaphone), Xiaomi Mi 10 Lite 5G with Netmonitor App.

The results received on the Netmonitor app and the Oscor green spectrum analyzer at the Meeting Room show that the frequency spectrum in this area is distributed in the following bands: band 700 APT (Viettel tests 5G in band 700), 4G bands 900, 1800+ (band 3), 2100 (band 1), etc. TDD2300 (Viettel tests 5G in band 40) and band TDD2600 (Vinaphone tests 5G in band 41). Results in Figure 13, 14 and 15 show frequency spectra in the range of -59 dBm to -113 dBm.

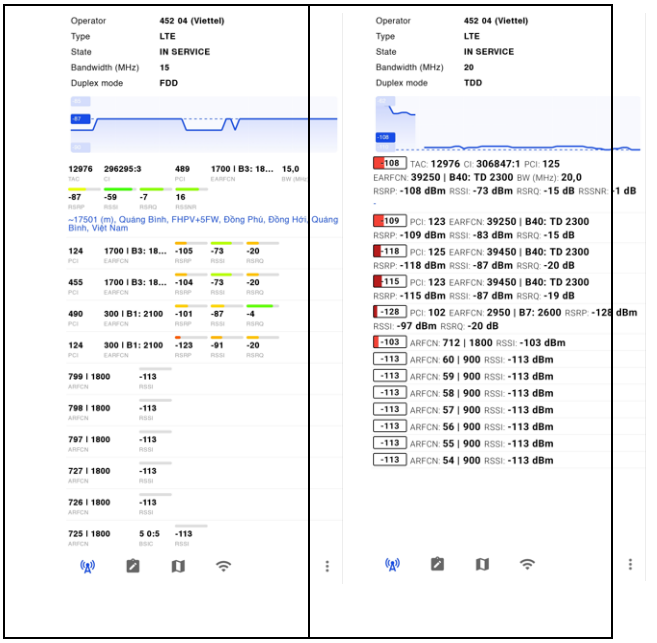


Figure 13. Results in Frequency Bands using Netmonitor

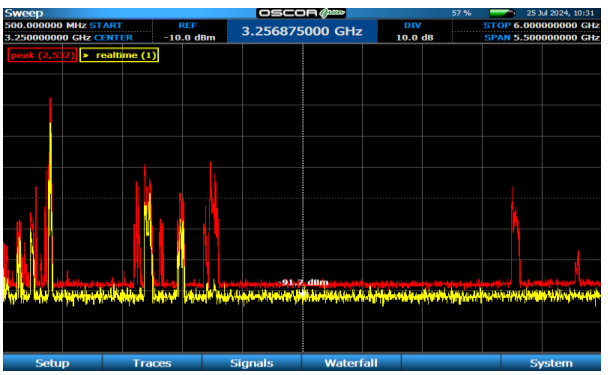


Figure 14. Results of measuring the base station spectrum using the Oscor Green

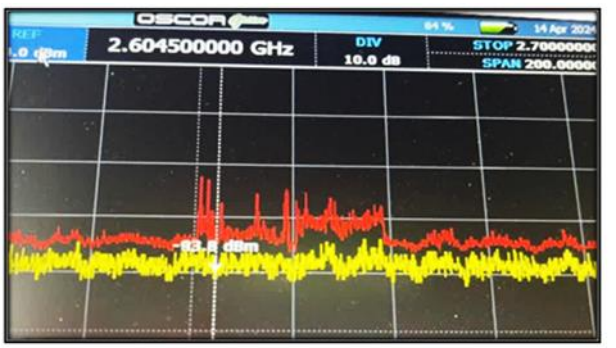


Figure 15. Results of measuring frequency 2600-band using the Oscor Green

After surveying the frequency spectrum in the meeting room area, the authors set up the process of testing the jamming device here in 2 steps as follows.

Step 1: Install the jammer at the end of the meeting room, then turn on the jammer.

Step 2: Change the position of the test phones around the meeting room, monitor the received signal through Netmonitor software and simultaneously measure the jamming frequency and bandwidth on the OSCOR green spectrum analyzer (Figure 16, 17,18).

Test results: after the 5G mobile communication jammer was activated, the phone devices all reported the status of no service, meeting the requirements set out in the study [1].

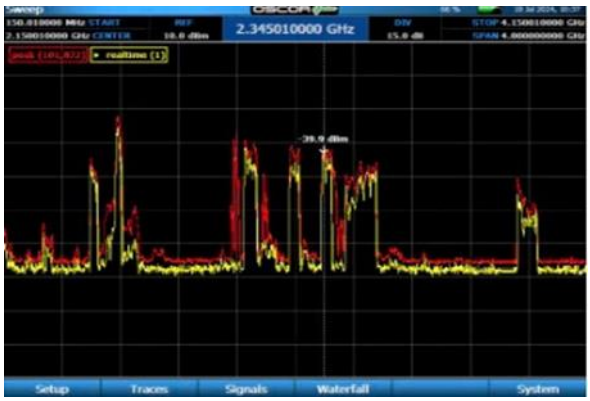


Figure 16. The results measured the jamming frequency spectrum on the OSCOR Green

Figure 17. The results measured of the jammer in the 2500 MHz to 2690 MHz band on OSCOR Green

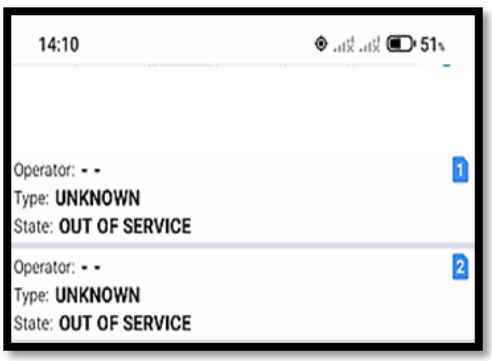


Figure 18. The status no service on the phones of network operators measured through Netmonitor software

D. Evaluate the results

At the two test sites, the measured results for the jammer met the requirements in the study [1]. Compared with the proposal in [1], the authors researched the design and added an additional jamming block for the 3800 MHz band to suit the current time.

Initially, this is the first 5G mobile phone jammer to be researched and designed in the Public Security, the authors have mastered the design and manufacturing technique of mobile communications jamming devices suitable of 5G frequency bands for the conditions in Vietnam.

IV. Conclusion

Research and understanding of 5G mobile communications networks in Vietnam has contributed to optimizing the design and shortening the time to manufacture jamming devices. When we are self-sufficient in technology, we can be proactive in production, repair, warranty, maintenance, servicing, and repair of devices. This is the direction of applied research at the same time bringing economic and work efficiency.

The next research direction of the authors will focus on understanding smart jamming solutions, when in September 2024 Vietnam begins the roadmap to turn off 2G.

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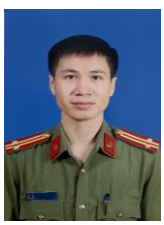

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