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BROADBAND WIRELESS COMMUNICATION IN THE TERAHERTZ RANGE: THE KEY TO THE SUSTAINABILITY OF THE DIGITAL ECONOMY

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ШИРОКОСМУГОВИЙ БЕЗДРОТОВИЙ ЗВ'ЯЗОК В ТЕРАГЕРЦОВОМУ ДІАПАЗОНІ : ЗАПОРУКА СТІЙКОСТІ ЦИФРОВОЇ ЕКОНОМІКИ

У статті наводяться новітні тенденції застосування частот терагерцового діапазону для створення новітніх стійких бездротових телекомунікаційних технологій і систем наступних поколінь, які дозволяють збільшити обсяг передачі інформації, масове підключення пристроїв та безпечну передачу даних при зондуванні об'єктів з високою роздільною здатністю щодо забезпечення стійкості цифрової трансформації економіки і суспільства.

The article focuses on the latest trends in using terahertz band frequencies to create sustainable next-generation wireless telecommunications technologies and systems. These technologies and systems enable increased information transmission, mass device connectivity, and secure data transmission. Additionally, they can sense high-resolution objects for a sustainable digital transformation of the future economy.

The shared digital future of society depends on the growing number of devices, services, and products in the limited radio frequency spectrum. In Ukraine, identifying and agreeing on the availability of spectrum is crucial for achieving cost-effective deployment of communication services. Increased coverage and bandwidth are crucial within the framework of the World Radiocommunication Conference, ITU WRC-23 [1]. This conference regulates the use of radio frequency spectrum, as well as geostationary satellite and non-geostationary satellite orbits.

The terahertz (THz) electromagnetic spectrum lies between the mm-wave (*mmWave*) and far-infrared (IR) bands and provides much higher bandwidth compared to the *mmWave* band and more favorable propagation conditions compared to the IR band. THz frequencies promise to provide a wide spectrum, data transfer rates of more than a hundred gigabits per second (Gbps), mass connectivity, denser networks and highly secure data transmission. The U.S. Defense Advanced Research Projects Agency (*DARPA*) has identified THz technology as one of four major research areas. It is also considered a major component of the next phase of telecommunications. This technology may have a greater impact on society than the Internet itself.

Among the main areas of application of the terahertz band, the International

Telecommunication Union (*ITU*) has identified several main areas, namely: mobile broadband expansion (*eMBB*), machine-type communication (*mMTC*) and mobile broadband expansion (*eMBB*). *mMTC* communications and ultra-reliable low-latency communications (*uRLLC*) are defined to support a wide range of traditional and emerging applications and services anytime, anywhere [2]. With *mmWave* communication becoming an industrial standard, the *IEEE ComSoc* has emerged as a key communication platform. Given this trend, there is a growing need to explore new wireless technologies that operate in the THz range, which is the next frontier beyond *mmWave* [3].

By 2030, 6G networks are expected to be a key enabler of the intelligent information society, providing higher performance than 5G in space, air, land, and underwater networks. These networks will enable ubiquitous and unlimited wireless communication, based on the integration of various promising radio access technologies for the 6G ecosystem, including THz communication [4].

The large bandwidth available at terahertz frequencies can offload low-frequency bands and provide speeds in the multi-gigabit range for future wireless systems, enabling unprecedented levels of data transfer, including massive multicore wireless networks on a chip, terabit-per-second wireless personal networks, broadband transit for Internet access in rural areas and high-speed inter-satellite connections.

In connection with the growth of the number of telecommunication systems that use electromagnetic radiation of various frequency ranges, there is a need to create new sustainable wireless telecommunication technologies and systems. These should allow for an increase in the amount of information transmitted while maintaining an environmentally safe level of radio radiation. Already, American scientists from NASA's Jet Propulsion Laboratory (JPL) are engaged in the development and integration of aerospace warfare technologies. They have managed to achieve terahertz signal transmission at a speed of 2 Gbps over a distance of 2.03 km without a bit error rate (BER). This achievement is expected to contribute to the development of 6G and the sustainability of the digital ecosystem [5].

For the 6G ecosystem and wireless communication networks of the next generation, in the scientific literature, scientists consider the need to use subterahertz and terahertz frequency ranges from 100 GHz to 10 THz. This is necessary to provide multi-kilometer and multi-gigabit-second sub-terahertz communication for wireless transit programs [6].

The need to provide higher wireless data rates for the ever-increasing number of devices connected to a wireless network is driving the search for a spectrum of radio frequency resources that is not yet in use. The Government of Ukraine has taken the first steps to carry out the conversion of the radio frequency resource of Ukraine [7] This is aimed at improving access to the mobile Internet in the radio frequency bands of 790–960 MHz and the conditions for the compatible functioning of the radio-electronic means of special users of the radio frequency resource with the radio-electronic means of mobile communication networks. These efforts have made it possible to conduct research on innovative communication applications in the terahertz range [8].

However, there are many technological innovations that have yet to be explored. For example, the use of machine learning algorithms in wireless networks is a promising area of research that could greatly improve network performance and efficiency. Additionally, the implementation of advanced modulation schemes, such as orthogonal frequency division multiplexing (OFDM) and filter bank multicarrier (FBMC), could provide higher spectral efficiency and better resistance to interference. Further exploration of these and other innovations could lead to significant improvements in the design and operation of future wireless systems. The prospect of large contiguous bandwidths in the communications industry is a key research area for 6G wireless communication. This is due to the need to meet the demand for ultra-high data rates in the Tbit/s range with low latency while ensuring robust co-communication and radar sensing.

THz waves are promising for use in many applications in spectroscopy and high-resolution imaging, since many forms of condensed matter, molecular compounds, vapours, and gases have different physical properties that resonate with THz waves [9]. Terahertz waves allow for non-destructive control of products and do not have an ionizing effect.

Also emerging is a concept that uses wireless frequencies for both communication and sensing capabilities, namely joint communication and sensing. Terahertz frequencies would not just transmit data, but could work like a high-precision radar system to detect objects. Thus, THz sensing can provide high-resolution maps of the environment and positioning and location information with centimeter and subcentimeter accuracy.

References

1. International cooperation. URL: https://www.ucrf.gov.ua/pres-centr/news/mizhnarodna-spivpratsia_1
2. Convergence of Broadband and Broadcast/Multicast in Maritime Information. URL: Networks https://www.sciopen.com/article_pdf/1425373508562079745.pdf
3. Sixth IEEE International Workshop on Terahertz Communications in conjunction with IEEE Global Communications Conference Thursday, 8 December 2022, 8am BRT // Rio de Janeiro, Brazil. URL: https://www.thz-comm.org/
4. 6G Wireless Networks: Vision, Requirements, Architecture, and Key Technologies. URL: https://ieeexplore.ieee.org/document/8766143
5. Researchers Achieve 2Gbps Terahertz Transmission over 2km. URL: https://www.6gworld.com/exclusives/researchers-2gbps-terahertz-transmission-2km/
6. Multi-kilometre and multi-gigabit-per-second sub-terahertz communications for wireless backhaul applications. URL: https://www.nature.com/articles/s41928-022-00897-6
7. Some issues of the conversion of the radio frequency resource of Ukraine in the public radio frequency bands: Resolution of the CMU of September 5, 2014 No. 514. URL: https://zakon.rada.gov.ua/laws/show/514-2014-%D0%BF#Text
8. On some measures to improve access to the mobile Internet: Decree of the President of Ukraine dated 07/08/2019 No. 497. URL: https://zakon.rada.gov.ua/laws/show/497/2019#Text
9. Mess- und Automatisierungstechnik. URL: https://www.vdi.de/tg-fachgesellschaften/vdi-gesellschaft-mess-und-automatisierungstechnik