

1 СЕКЦІЯ «РАДІОТЕХНІЧНІ ТА ТЕЛЕКОМУНІКАЦІЙНІ СИСТЕМИ, ІНФОРМАЦІЙНІ ТЕХНОЛОГІЇ В ПРОЄКТУВАННІ ТА ВИРОБНИЦТВІ»

УДК 621.396.965

Vasiuta Kostiantyn¹, Kazmirov Ivan²

1 Deputy Head in Science of Ivan Kozhedub Kharkiv National Air Force
University, Professor, Doctor of Engineering Science

2 Post-Graduate of Ivan Kozhedub Kharkiv National Air Force University

PROSPECTS FOR THE DEVELOPMENT OF ON-BOARD RADIO- LOCATION SYSTEMS

The report outlines the main characteristics of modern on-board radar systems and defines the development directions of future on-board radars. Airborne radar systems are highly technological due to high-quality standards and limited space on board an aircraft. Modern fighters such as the F-22 and F-35 are equipped with an adaptive airborne radar system with a low probability of interception (LPI). Such radars use a special radiated waveform designed to prevent interception and detection of its radiation. For example, the AN/APG-77 radar is an advanced multi-mode tactical radar for the F-22 fighter jet built by Northrop Grumman with Raytheon. Thanks to such an adaptive radar, the F-22 aircraft can detect air targets in such a way that the exposure warning system of these aircraft with a high probability will not detect the fact of their exposure. The AN/APG-77 radar emits pulses of low power in a wide frequency range. The emitter changes the frequency and power level after each pulse so that no two pulses are identical. When multiple reflected signals are sent back to the radar, the signal processor converts the signals together rather than individually. The radar is equipped with an active electronically scanned array, which contains 2000 transmission and reception modules. The active array provides fast frequency change, low detectable effective target scattering area, flexible beam control, and wide bandwidth characteristics of LPI radars [1]. The next generation of the F-22 radar is the AN/APG-81 radar installed on the F-35 fighter.

The airborne radar system AN/APG-81 and its upgraded version AN/APG-85, which also uses LPI technology in operation, are advanced developments of Northrop Grumman Electronic Systems. The active electronically scanned array of these radars has 1,676 receiving and transmitting modules with solid-state high-frequency amplifiers based on gallium arsenide (GaAs). The team that created the AN/APG-81 radar received the David Packard Excellence in Acquisition Award in 2010 for the effectiveness of operation under conditions of radio-electronic interference. In January 2023, it was reported that the AN/APG-81 radar on F-35

fighters would be replaced in the future with the newer AN/APG-85 radar, which is scheduled to go into production in 2025. The AN/APG-85 is designed to be easily integrated with other aircraft systems, including electronic warfare systems, weapons control systems, and communications systems, ensuring full integration with the aircraft's overall systems. [2-3].

Over the past decade, the next step in the evolution of LPI radars, called cognitive radars, has taken shape. It is a radar system that in a sense displays intelligent data, adapting its operation and signal processing in response to changing environments and circumstances. Like LPI radars, cognitive radars also change the power and frequency of the signal for stealth and adaptation to environmental influences (operation of radio-electronic suppression of the enemy or interference of the underlying surface when irradiating ground targets). Compared to adaptive radar, cognitive radar learns to adapt operating parameters as well as processing parameters and can do so over a long period [4]. That is, unlike LPI radars, cognitive radars not only adapt the frequency of the emitted signal but can also change the shape of the signal and “learn from mistakes”, because cognitive radars can have several types of memory, which, acting together, allow the radar to predict the consequences of the actions taken by the radar as a whole.

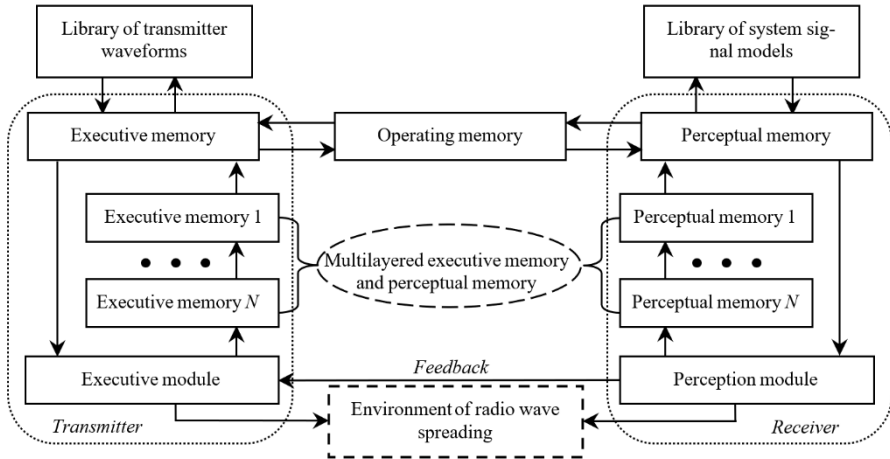


Figure 1 – Functional scheme of the on-board cognitive radar with memory [5-6]

In the perception-action cycle, which is the basis for the work of every dynamic cognitive system, three types of memory are distinguished:

- memory of perception (information from the input of the receiver) which is a constituent part of the receiver;

- executive memory, which is a constituent part of the transmitter;
- operating memory, which combines executive memory with memory of perception.

The functional diagram shown in Figure 1 is a simplified structure of cognitive radar with memory, cognitive properties arise with different types of memory. The multi-layered memory of perception stores knowledge based on experience gained in the process of learning from changes in the environment, that is, the content of the memory is constantly changing as a result of environmental influences, for example, troublemakers. Multilayered executive memory uses previously acquired knowledge stored in perceptual memory to shape a response to a change in the environment. Also, it is no less important that the correction of multilayer memory is performed with the help of feedback through the operating memory since errors occur over time when accumulating information in multilayer memory [5-6].

Thus, in the construction of promising on-board cognitive radars, it is proposed to use: a cognitive approach to the formation of radar signals, a signal processor, the use of several types of memory, solid-state high-frequency amplifiers for the output amplification of the transmitter signal, and the use of neural networks, for example, convolutional networks, which are used for image analysis [7]. The concept of cognitive radars is promising in synthesizing airborne radars for gaining superiority in airspace, effectively detecting air and ground targets, and tracking targets using the intellectual and training properties of cognitive radars.

REFERENCES

1. Pace P. E. Detecting and classifying low probability of intercept radar. – Artech house, 2009 – p. 893.
2. Northrop Grumman Developing the Next Generation Radar for the F-35 Lightning II. *Northrop Grumman Newsroom*. URL: <https://news.northropgrumman.com/news/releases/northrop-grumman-developing-the-next-generation-radar-for-the-f-35-lightning-ii>.
3. AN/APG-81 Active Electronically Scanned Array (AESA). Northrop Grumman. *Northrop Grumman*. URL: <https://www.northropgrumman.com/what-we-do/air/an-apg-81-active-electronically-scanned-array-aesa-fire-control-radar>.
4. “IEEE Standard for Radar Definitions” in IEEE Std 686-2017, 2017. – p.15. DOI: 10.1109/IEEESTD.2017.8048479
5. Haykin S. Cognitive dynamic systems: perception-action cycle, radar and radio. – Cambridge University Press, 2012. – p. 332. <https://doi.org/10.1017/CBO9780511818363>.

6. Guerri J. R. Cognitive radar: A knowledge-aided fully adaptive approach. IEEE Radar Conference. – IEEE, 2010. – pp. 1365-1370. DOI: 10.1109/RADAR.2010.5494403

7. S.Z. Gurbuz, S. Bruggenwirth, T. Reininger, A.C. Gurbuz, G.E. Smith. The role of neural networks in cognitive radar. – Next-generation cognitive radar systems, 2023. – p. 371-419. https://doi.org/10.1049/SBRA552E_ch12.