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Software Defined Radio: Enhancing Communication Capabilities

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'Software Defined Radio' (SDR) is used by the forces to transfer voice, data, and video information. Now, with the indigenised SDR technology, the possibility of swarms of drones operating on future battlefields seems possible.

SDR is a radio communication system where traditional hardware components, such as mixers, amplifiers, filters, modulators and demodulators, detectors, etc., are replaced with software running on a personal computer, embedded system, or another digital device. This system enables a single device to communicate on multiple frequencies and protocols, making it highly flexible and adaptable.

The fundamental tenet of the SDR is that the software can completely configure or define the radio. In an ideal world, the incoming signal is immediately converted to a digital format, which is then processed digitally. SDR can have multiple types of waveforms, including wideband and narrowband applications.

Basic SDR Architect

'SDR' is a concept according to which the radio frequency (RF) communication is achieved by using software (or firmware) to perform signal-processing tasks that are typically performed by hardware. A SDR (the device itself) is an RF communication system that incorporates much of this software-based signal-processing functionality.

Any system that uses radio waves to send and receive data does so in the RF band. Milind Kulshreshtha, an expert in Artificial Intelligence (AI) and command, control, communications, computers, and intelligence (C4I), describes it as "a very unique type of advanced Radio system in which the physical layer functions are defined as software functionality," in other words, a software code executes the role of a circuit board of the conventional radio, and software-based filtering algorithms are used for frequency selection.[1]

Most RF communication systems still need to be updated and implemented in hardware. SDRs require extensive software development and a complicated printed circuit board (PCB) design. In addition, the essential components—high-performance data converters and a sturdy processor—are not cheap. Compare all this to a single-chip, highly integrated transceiver (such as this one) that takes care of numerous details and gives you pages of performance data so that you know approximately what your system will be capable of before you even open up your schematic editor.

Operational Advantages of SDR

SDR has various operational advantages like any technology. Some of these are:[2]

(a) *Flexibility:* SDR systems can be easily reconfigured to support different communication protocols and frequency bands, allowing real-time adaptation to changing operational requirements. SDR's adaptability stems from its ability to dynamically choose an operating frequency and mode that are optimally suited to the current circumstances.

(b) *No Interferences*. The capability to recognise and avoid interference with other communications channels increases the "signal-to-noise" ratio. The resultant output is clear with adequate signal levels.

(c) *Interoperability*: SDR systems can be used to communicate with different types of radios, which allows for greater interoperability between military units and coalition partners.

(d) *Security:* SDR systems can use advanced encryption and protocols to protect communication from interception or hacking, providing greater operational security and resilience. In addition, the ease of developing new protocols in SDR systems adds strength.

(e) *Spectrum efficiency*: SDR systems enable multiple users to share the same frequency band without interference, allowing for more efficient use of limited spectrum resources.

(f) *Simplification of Radio Architectures*: Elimination of analogue hardware and its cost, resulting in generalisation of radio architectures and enhanced performance;

(g) *Portable*: SDR systems can be more compact and lighter than traditional radio systems, which can be a strategic advantage for military units operating in austere environments or on the move. Reduced weight and size provide the portable capability, thus enabling its tactical exploitation.

Limitations: Like any other communication system, SDR, too, has specific constraints. A few of these are:

(a) Complexity: SDRs are more complex to design and implement than traditional radio systems. SDR systems, therefore can be more expensive than traditional radio systems due to the need for specialised hardware and software. SDR systems require high technically skilled expertise to operate and maintain, which can be a challenge for some forward military units with complex accessibility.

(b) Security: There is a possibility that SDRs are more vulnerable to hacking or other security threats than conventional radio systems. This is because traditional radio systems are less sensitive to interference from other radio sources than SDRs.

(c) Power Consumption: SDR systems can consume more power than traditional radio systems, especially when operating at high frequencies. Higher power consumption may be a concern in environments with limited power sources.

Software-Controlled v/s Software-Defined Systems

A typical hardware-based RF communication system can be modified in some way via software. For example, suppose a radio has hardware for both frequency modulation and amplitude modulation and allows the user to choose between the two by means of a software (or firmware) setting. In that case, we are not dealing with SDR. This system might be called a software-controlled radio. This is because the "software" in "software-defined radio" does not refer to the fact that the system transfers digital data.

In terms of cost and simplicity, SDRs cannot compete with single-chip hardware-based solutions. Nevertheless, they are interesting and valuable tools for R&D projects, and they also enable advanced functionality that could be very beneficial in specialized, high-performance RF systems.

Operational Importance

SDR has become increasingly important in modern warfare due to its ability to provide secure, reliable, and flexible communication in dynamic and complex battlefield environments. SDR can be used to transmit and receive voice, data, and video signals and can be easily reconfigured to support different communication protocols and frequency bands, allowing for real-time adaptation to changing operational requirements.

SDR enables advanced encryption and security protocols to protect communication from interception or hacking, providing greater operational security and resilience.

The significance of SDR in modern warfare lies in its ability to provide reliable, flexible, and secure communication in dynamic and complex battlefield environments, enabling military personnel to communicate effectively and make informed decisions in real time.

SDR systems also offer enhanced spectrum efficiency, enabling multiple users to share the same frequency band without interference. Such an arrangement is essential in military operations where numerous units, vehicles, and aircraft must communicate simultaneously.

SDR in Military Use

Defence Tactical communication operates at several different frequencies like High Frequency (HF), Very/Ultra High Frequency (V/UHF), and each follows a different set of protocols designed to accommodate the rigours of warfare. A tactical communication strategy is made up of individual units, or nodes and forms part of an interconnected and secure network for communicating with each other. SDR, too, operates in the same frequency ranges using multiple protocols.

The Indian Army, Air Force, and Navy have all been working towards the development of a family of modular and interoperable SDRs versions, including "Manpack (SDR-MP), Hand Held (SDR-HH), Airborne (SDR-AR), Naval Combat (SDR-NC), and Tactical (SDR-TAC)" These versions are currently in the process of being tested and evaluated.

IAF is exploring SDR technology for its tactical communications and network-centric operations. SDR is a radio communication system that uses software to handle signal-processing functions that are traditionally performed by hardware, allowing it to support several wireless technologies and standards.[3]

According to reports, the IAF has been working with the Defence Research and Development Organisation (DRDO) and the Indian Institute of Technology (IIT) Kanpur to develop an indigenous SDR platform to meet its operational requirements. The IAF is also interested in procuring SDRs from domestic and foreign vendors for its aircraft, helicopters, and ground stations.[4]

DRDO: Developing SDR

The indigenization of SDRs is expected to be expedited so that the Indian Armed Forces can meet their demand across a wide range of operational domains. According to the Ministry of Defence (MoD) official statement issued by on Tuesday, the Indian Institute of Technology (IIT) Kanpur and the DRDO are working together to indigenise the SDR.

The Indian Defence Department has developed the communication waveform algorithms that are used by SDR; this contributes to the SDR system's high level of security.[5] The Indian Army is revamping its communication systems by procuring "V/UHF Manpack SDRs under the Make-II category".

The indigenous development of SDR technology is a significant achievement essential to the realisation of 'Atmanirbhar Bharat' in this sphere of endeavour. After it has been manufactured in India, this indigenous technology will be made accessible to the Indian Army and the Indian Air Force so that they can put it into use.

After successfully evaluating vendor responses, a Project Sanction Order (PSO) has now been issued to 18 Indian vendors to start prototype development. The contract will be placed with one of the firms after a successful outcome as per the provisions of the Buy (Indian-IDDM) category of Defence Acquisition Procedures (DAP) 2020.[6]

Conclusion

SDR systems have the potential to provide significant strategic advantages to military forces by improving communication, enhancing operational flexibility, and enabling greater situational awareness. However, these advantages must be weighed against the limitations and costs of deploying and maintaining SDR systems. The armed forces use this SDR to facilitate the rapid transfer of voice, data, and video information.

To safeguard and ensure the safety of sensitive SDR technology and goods, the practice of life cycle management is not only highly significant but also essential. In addition, this process

comprises the creation of an indigenous ecosystem for development, production, design, testing/certification, and maintenance. In view of versatility of the SDR for the armed forces, adequate attention towards its R&D merits consideration by Indian planners.

(Disclaimer: The views and opinions expressed in this article are those of the author and do not necessarily reflect the position of the Centre for Air Power Studies [CAPS])

Notes:

[1] Huma Siddiqui, 'Make in India' Software Defined Radio: 'Mother' of all solutions for tactical communications of armed forces, August 20, 2019, https://www.financialexpress.com/defence/make-in-india-software-defined-radio-mother-of-all-solutions-for-tactical-communications-of-armed-forces/1680536/. Accessed on April 30, 2023.

[2] "Why SDR (Software Defined Radio)?", Red Pitaya, August 11, 2022, https://content.redpitaya.com/blog/why-sdr-software-defined-radio. Accessed on April 30, 2023.

[3] Ibid FE.

[4] Huma Siddiqui, "Aatmanirbhar Bharat: Software Defined Radios for the Armed Forces to be made in India", The Financial Express, July 26, 2022, https://www.financialexpress.com/business/defence-aatmanirbhar-bharat-software-defined-radios-for-the-armed-forces-to-be-made-in-india-2607327/. Accessed on April 30, 2023.

[5] Ibid FE.

[6] "Software Defined Radio (SDR) for Indian Army under Aatmanirbhar Bharat Abhiyaan", PIB Delhi, February 18, 2021, https://pib.gov.in/PressReleseDetailm.aspx?PRID=1699066. Accessed on April 30, 2023.