TEXNİKA ELMLƏRİ

TECHNICAL SCIENCES

DOI: https://doi.org/10.36719/2663-4619/101/256-261

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BASIC PRINCIPLES OF RADIO COMMUNICATION

Abstract

Radio communication operates on the fundamental principles of transmitting and receiving electromagnetic waves that carry information across distances without the need for physical connections. At its core, radio communication involves the conversion of information into a radio signal, which is then transmitted through the air using electromagnetic waves of a specific frequency. The process starts with the generation of a radio frequency (RF) carrier wave, which is modulated with the input signal containing the information to be transmitted. This modulation can be achieved in several ways, including amplitude modulation (AM), where the amplitude of the carrier wave varies with the input signal, and frequency modulation (FM), where it's the frequency of the carrier wave that varies.

Upon reaching its destination, the transmitted signal is captured by an antenna connected to a radio receiver. The receiver demodulates the signal, extracting the original information from the carrier wave. This is achieved through a process that effectively reverses the modulation step performed at the transmitter. The receiver must be tuned to the specific frequency of the transmitted signal to successfully retrieve the information.

One of the critical aspects of radio communication is the selection of the transmission frequency, which affects the propagation characteristics and the range of the communication. Higher frequencies offer greater bandwidth and potential data rates but typically have shorter range and are more susceptible to line-of-sight limitations and atmospheric absorption. Lower frequencies, in contrast, can travel longer distances and are better at penetrating obstructions but offer limited bandwidth for data transmission.

The principles of radio communication have been refined over the years to accommodate a growing demand for wireless communication services, leading to the development of various standards and technologies that enhance the efficiency, reliability, and security of radio communication systems. These advancements have facilitated a wide range of applications, from broadcasting and mobile telephony to satellite communication and wireless networking, demonstrating the versatility and enduring relevance of radio as a medium for communication.

Keywords: *Radio communication, radio frequency, modulation, radio receiver, radio signal*

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Radio rabitənin əsas prinsipləri

Xülasə

Radio rabitəsi fiziki əlaqəyə ehtiyac olmadan məsafələr arasında məlumat daşıyan elektromaqnit dalğalarının ötürülməsi və qəbul edilməsinin əsas prinsipləri əsasında fəaliyyət göstərir. Əsasən, radio rabitəsi məlumatın radio siqnalına çevrilməsini nəzərdə tutur, daha sonra müəyyən tezlikli elektromaqnit dalğalarından istifadə edərək hava ilə ötürülür. Proses ötürüləcək məlumatı ehtiva edən giriş siqnalı ilə modulyasiya edilən radiotezlik (RF) daşıyıcı dalğasının yaradılması ilə başlayır. Bu modulyasiya bir neçə yolla əldə edilə bilər, o cümlədən daşıyıcı dalğanın amplitudasının giriş siqnalı ilə dəyişdiyi amplituda modulyasiyası (AM) və daşıyıcı dalğanın tezliyi dəyişən tezlik modulyasiyası (FM).

Təyinat yerinə çatdıqdan sonra ötürülən siqnal radio qəbuledicisinə qoşulmuş antena tərəfindən tutulur. Qəbuledici siqnalı demodulyasiya edir, daşıyıcı dalğadan orijinal məlumatı çıxarır. Bu, ötürücüdə həyata keçirilən modulyasiya addımını effektiv şəkildə geri qaytaran bir proses vasitəsilə əldə edilir. Məlumatı uğurla əldə etmək üçün qəbuledici ötürülən siqnalın xüsusi tezliyinə uyğunlaşdırılmalıdır.

Radiorabitənin kritik aspektlərindən biri rabitənin yayılma xüsusiyyətlərinə və diapazonuna təsir edən ötürmə tezliyinin seçilməsidir. Daha yüksək tezliklər daha çox bant genişliyi və potensial məlumat sürəti təklif edir, lakin adətən daha qısa diapazona malikdir və görmə xəttində məhdudiyyətlərə və atmosferin udulmasına daha çox həssasdır. Aşağı tezliklər, əksinə, daha uzun məsafələr qət edə bilər və maneələri daha yaxşı keçir, lakin məlumat ötürülməsi üçün məhdud bant genişliyi təklif edir.

Radio rabitəsinin prinsipləri illər ərzində simsiz rabitə xidmətlərinə artan tələbatı ödəmək üçün təkmilləşdirilmiş və radio rabitə sistemlərinin səmərəliliyini, etibarlılığını və təhlükəsizliyini artıran müxtəlif standartların və texnologiyaların inkişafına gətirib çıxarmışdır. Bu irəliləyişlər radio yayımı və mobil telefoniyadan tutmuş peyk rabitəsi və simsiz şəbəkəyə qədər geniş spektrli tətbiqləri asanlaşdıraraq, radionun rabitə vasitəsi kimi çox yönlü və davamlı aktuallığını nümayiş etdirir.

Açar sözlər: *Radiorabitə, radiotezlik, modulyasiya, radioqəbuledici, radiosiqnal*

Introduction

Radio communication, introduced in the early 20th century, is a telecommunication system that utilizes electromagnetic waves to transmit and receive data. This system was pioneered by Guglielmo Marconi and has since evolved to support even transcontinental telegraph communications. The first radio relay line with 5 telephone channels was established in 1935 between New York and Philadelphia in the USA. The advancement of radio relay (RR) communication technology saw rapid expansion from the 1950s, with the mid-1970s marking the deployment of an 8-circuit RR line spanning 10,000 km and supporting 1,800 telephone channels each. By the 80s and 90s, dense RR networks had been developed in all advanced countries.

Radio relay communication, executed through a series of transmitting and receiving stations, is crucial for enabling continuous signal transmission over long distances (William, 1987). Stations are typically positioned within direct line-of-sight of each other, each amplifying and forwarding the signal from one station to the next. This relay system primarily utilizes decimeter and centimeter waves for multi-channel broadcasting of television, telephone, and telegraph signals. The choice of these frequencies allows for the efficient use of the radio spectrum, supporting numerous concurrent transmissions while minimizing atmospheric and industrial interference (Ian, Glover, Peter, Grant, 1998).

The direct visibility required for decimeter (dm) and centimeter (cm) waves necessitates the construction of numerous relay stations to cover significant distances (Peter Lewis 1994). To extend the range between stations, antennas are mounted on tall towers, typically 70-100 meters high, allowing for standard distances of 40-50 km between ground-level stations. Tropospheric communication can further extend these distances to 250-300 km under certain conditions, demonstrating the strategic deployment of relay stations to maximize coverage and connectivity (The ARRL Handbook for Radio Communications, 2021).

The development of Radio Relay Link (RRL) technology has expanded rapidly since the 1950s, thanks to advancements in electronic communication techniques. By the mid-70s, a complex of reengineered devices for an RRL line extended 10,000 km with each of its eight circuits supporting 1800 telephone channels. By the 80s and 90s, dense RRL networks had been established in all developed countries (Roger, 2007). An RRL station, part of the RRL line, plays a crucial role in multi-channel communication and television program transmission (Constantine, 2016).

RRL stations are categorized into three groups: terminal RRL stations, junction RRL stations, and intermediate RRL stations. The intermediate RRL station, controlled automatically by the terminal and junction RRL stations, performs the function of an amplifying repeater. The main challenges for RRL communication are radio interferences that degrade signal quality (Christopher, 2008).

Operational modes of an RRL station include:

- The terminal RRL station, which converts information signals to radio signals for transmission and vice versa (Grigorios, 2009).
- The junction RRL station, which separates all or part of the signals received from primary RRL stations and redirects them to a communication hub, combining them with newly placed signals for further transmission.
- The intermediate RRL station transmits received signals to the next station in line (Bruce, 2009).

Radio interferences, unrelated to the signal and caused by electrical or electromagnetic effects, significantly impact the quality and reach of the transmitted signal. These interferences are categorized based on their origin and source into cosmic, atmospheric, industrial, and those created by other radio stations, whether intentional or accidental, as well as interferences arising from the propagation characteristics of radio waves and the intrinsic noise of the receiver (Theodore, 2009).

A transmitting radio station with known coordinates on the Earth's surface is referred to as a radio beacon. This enables moving objects, like ships and aircraft, to determine their direction relative to the beacon and adjust their course accordingly by receiving signals from the beacon.

In radio communication systems, transmission refers to the linear path through which an electrical communication signal is sent through open space using radio waves. Modern radio relay communication allows for the transmission of various types of information, including telephone, telegraph, photo telegraphy, television, audio broadcasts, newspaper pages, digital data, and more. The primary method used in radio relay communication for transmitting information involves the frequency division of signals, which is widely utilized in practice. Digital transmission of signals is deemed more suitable in this context due to its inherent advantages. These include:

1. The simplicity of separating signals based on frequency,
2. The capabilities for channel switching.

Despite the diversity of transmissions within radio relay communication systems, the general structure of multi-channel radio relay communication remains consistent. This consistency underscores the system's flexibility in handling a broad range of information types, making it an integral part of contemporary communication networks (Valeria, Andrea, and Mohamed, 2013).

Radio relay communication can be categorized into different classes based on various characteristics, one of which is the radio frequency band utilized. Here is a breakdown of the classes according to the radio frequency band:

- 4th Band: Very Low Frequency (VLF) ranging from 3 to 30 kHz
- 5th Band: Low Frequency (LF) ranging from 30 to 300 kHz
- 6th Band: Medium Frequency (MF) ranging from 300 to 3000 kHz
- 7th Band: High Frequency (HF) ranging from 3 to 30 MHz
- 8th Band: Very High Frequency (VHF) ranging from 30 to 300 MHz
- 9th Band: Ultra High Frequency (UHF) ranging from 300 to 3000 MHz
- 10th Band: Super High Frequency (SHF) ranging from 3 to 30 GHz
- 11th Band: Extremely High Frequency (EHF) ranging from 30 to 300 GHz
- 12th Band: Terahertz or Tremendously High Frequency (THF) ranging from 300 to 3000 GHz.

Each frequency band has its specific applications, advantages, and limitations in terms of range, propagation characteristics, and the type of information it can carry effectively. These classifications enable the efficient allocation and use of the spectrum for various communication needs, including radio relay communications, which are pivotal in transmitting data over considerable distances without the need for physical cables.

Radio relay communication is divided into 2 parts: flat view and tropospheric communication.

In straight-line radio relay communication, the antennas of neighboring stations are located within the line-of-sight, the average communication distance is 40-7 km (Figure 1).

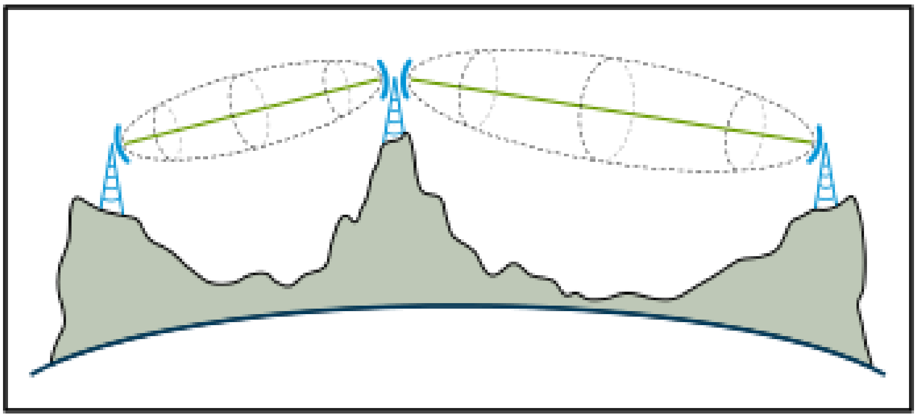

Figure 1: Straight-line radio relay communication

In tropospheric communication, the reflection effect of dm and sm radio waves from its turbulent and inhomogeneous layers in the troposphere is used, the communication distance is 300 km if there is no direct image between the stations (Figure 2).

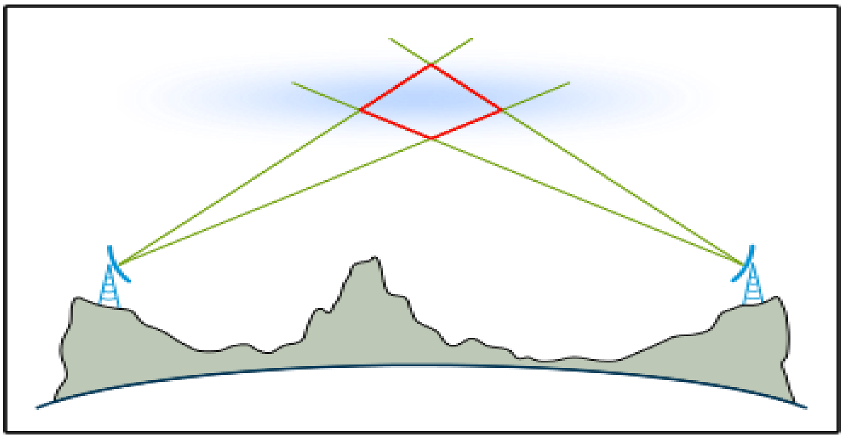

Figure 2: Tropospheric communication

The main feature of flat-view tropospheric radio relay communication is that the devices involved in this communication operate mainly in the dm and cm wavebands (UHF (ultra high frequency) and IHF (extreme high frequency). Because these bands are used to transmit broadband signals over long distances is more convenient.

In the dm and cm range, radio waves propagate over a 100 times greater distance than in the meter range (Louis, Frenzel, 2016).

Since long waves are greatly absorbed by the Earth's surface and ionosphere, radio communication between any radio stations on the Earth's surface is carried out by short waves. In underground communication, long and ultra-long waves are used. In underwater communication, along with long waves, waves in the optical range are used (Peter, 1994).

Conclusion

The transformation of information into electrical signals for transmission via radio communication highlights the sophistication and versatility of modern communication systems. By enabling the conversion of data into various signal forms, such as telephonic or telegraphic, and facilitating their transmission between transmitting and receiving stations, radio communication serves as a pivotal technology in bridging vast distances instantaneously. This process not only underscores the technical ingenuity behind radio communication systems but also emphasizes their critical role in ensuring seamless and efficient information exchange across the globe. The integration of initial electrical signals into a unified group signal further exemplifies the intricate processes involved in optimizing signal transmission, showcasing the ongoing advancements in communication technology that continue to enhance connectivity and information dissemination in an increasingly digital world.

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Received: 07.01.2024 Accepted: 22.03.2024