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Development of Electromagnetic Wave and its Applications

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***Abstract**. With the nonstop advancement of wisdom and technology, the variety of technological products around our lives has also increased, and numerous of them use the characteristics of electromagnetic waves. In order to make people more understand the applicable characteristics of electromagnetic waves, this composition will totally introduce the introductory proposition, bracket, operation and affiliated safety issues of electromagnetic waves. Electromagnetic weaves not only have a wide range of operations in diurnal life, similar as dispatches, remote seeing and other fields, but also play an important part in military and medical fields. Although electromagnetic weaves bring numerous conveniences, there are also certain safety pitfalls. Thus, understanding the nature and operation of electromagnetic waves to more cover our health and promote scientific and technological progress is important. In addition, for the limitations and failings of electromagnetic surge operations, it's also pivotal to explore implicit development directions, in order to achieve comprehensive and effective electromagnetic surge operations in the future.*

***Keywords:** Electromagnetic waves, application, limitations, potential development.*

1. INTRODUCTION:

In life, electromagnetic waves are extensively used in colourful fields, and they've also been deeply studied in the field of drugs (1). After studying some contents of electromagnetic waves in drugs in high academy, the author has a high interest in this content, so this paper uses this paper to further study the parcels and operations of electromagnetic waves. This paper analyses the introductory proposition of electromagnetic weaves including the bracket of electromagnetic waves, the exploration and development history of electromagnetic waves, and the generation of electromagnetic waves and the operation of contemporary electromagnetic waves, among which the operation of electromagnetic weaves is called in the service and medical aspects of life. At the end of this composition, the author summarizes the below and discusses the failings and unborn prospects of the current operation of electromagnetic waves.

2.BASIC THEORETICAL ANALYSIS OF ELECTROMAGNETIC WAVES

2.1. Classification of electromagnetic waves

Electromagnetic waves can be divided into radio waves, microwaves, infrared, visible light, ultraviolet light, X-rays and gamma rays. Fig.1. show the classification of electromagnetic wave.

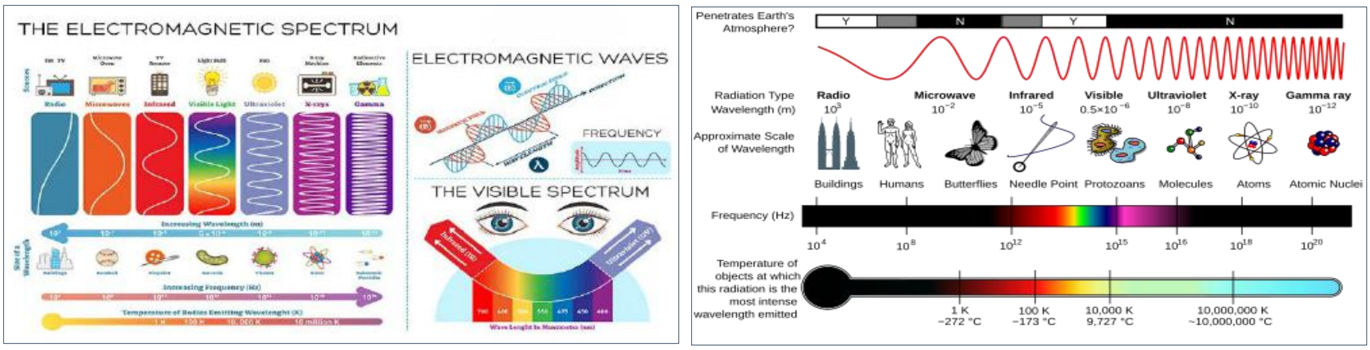

Figure 1. Electromagnetic waves Classification

In Fig.1. the frequency of radio wave ranges from 10 Hz to 10^8 Hz, it is often utilized in telecommunication and radio broadcast. Microwave's frequency is approximately 10^{10} Hz and Microwaves are a type of electromagnetic wave that shares similarities with radio, light, radar, and infrared waves. The main distinguishing factor is the frequency of the wave's motion [2]. When the frequency is larger than 10^{12} Hz but lower than 10^{14} Hz, the corresponding electromagnetic wave is infrared. Infrared is not only used in remote control, but in military field as well. Visible light possesses frequencies from10^{14} HZ to 10^{16}. 10^{16}Hz to 10^{19}Hz is a common frequency scope of ultraviolet. In people's daily life, it can be used in ultraviolet disinfection. 10^{18} Hz to 10^{22} and 10^{23} to 10^{26} HZ are frequencies of X-ray and gamma ray respectively. X-ray is most commonly utilized in medical field while gamma ray is capable to do industrial inspection. Gamma ray is also applied to gamma knife.

2.2 Generation of electromagnetic waves:

An electrically charged flyspeck creates an electric field. When charged patches move, electric and glamorous fields interact and impact each other, performing in electromagnetic waves. Taking the aluminium atom as an illustration, there are 13 negatively charged electrons outside the nexus, the middle is the nexus, and there are 13 appreciatively charged protons in the nexus, at this time, the number of positive and negative charges is equal, and the overall remains electrically neutral. Among them, the remotest electrons are more active and tend to fly out, if the outside with a positive electric field can fluently attract it to move. When the remotest electrons are attracted to detachment, the number of positive charges will be lesser than the number of negative charges, and the total will appear appreciatively charged, for convenience, the part with the same number of positive and negative charges is hidden to see the whole as a positive charge. Also, adding a redundant negatively charged electron to another aluminium atom, at this time the total is negatively charged, and the same number of corridors are also neglected as negative charge. When the positive and negative charges are close enough, an electric field with positive terminal pointing to negative outstation will be generated. The positive charge brace emits an electric field in each direction, and part of the electric field is an arc, and the waveform of the electric field emitted outward is largest when the distance is large. When fully near together, all electric fields are attracted by the negative charge, also arc disappears. According to the miracle of electromagnetic induction, A shifting glamorous field can induce a voltage in an electrical circuit. The changing electric field will produce a glamorous field, the direction of the glamorous field is vertical to the direction of the electric field, so such a glamorous field will be generated in the arc electric field, and the changing glamorous field will also produce an electric field, as long as the nonstop change of oscillation will continue to propagate, also electromagnetic waves are formed (3).

2.3 Development history of electromagnetic waves:

The development history of electromagnetic waves is shown in Fig. 2.

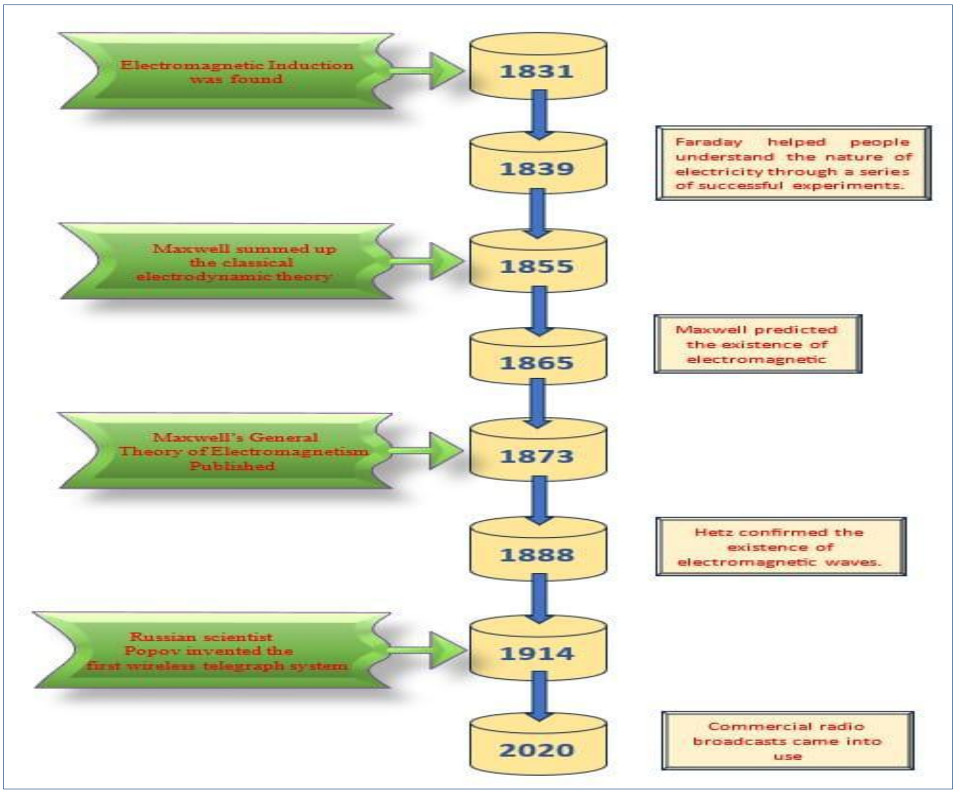

Figure 2. The development of electromagnetic waves

The British scientist Faraday began a series of crucial experiments in 1981. Phenomenon of electromagnetic induction, proving to the world that changing the glamorous field will produce an electric field. The law of electromagnetic induction, which is a quantitative representation of this miracle, was also discovered by Faraday. Faraday set up that if the glamorous field of an electromagnet was made to expand and contract by opening and closing the electrical circuit of which it was an element, an electrical current could be detected in another near captain. Also, a line coil could also induce a current while an endless attraction was being moved by and out of it. Also, whenever a captain was moved near a stationary endless attraction and as long as it was in stir, a current flowed in the line. In his after times, he demonstrated his profound physical ideas by proposing that the electromagnetic force not only exists in operators, but also extends into hard space (3).

James Clerk Maxwell began to study electromagnetism in 1855, and grounded on the achievements of his forerunners, through superb fine attainment and imagination, published three significant papers- “On Faraday's Lines of Force”, “On Physical Lines of Force”, “A dynamic proposition of the electromagnetic field”. This methodical and comprehensive study of electromagnetic marvels summarizes and summarizes the work of forerunners (4). After being rewritten and organized, these three papers came classic electrodynamics proposition. In 1865, Maxwell prognosticated the actuality of electromagnetic waves and concluded through theoretical logic that electromagnetic waves can only be indirectly conducted waves, and the propagation speed is equal to the speed of light. Maxwell also revealed the connection between light and electromagnetic phenomena, proving that light is a form of electromagnetic waves. In 1873, Maxwell published the well- known General Theory of Electromagnetism, which latterly deeply impressed the German physicist Heinrich Rudolf Hertz. Hertz studied Maxwell’s proposition of electromagnetism and experimentally demonstrated the actuality of electromagnetic waves in 1888. He also refocused out that electromagnetic waves can be reflected, refracted and concentrated at the same speed as the speed of light (5).

From 1888 to the present, electromagnetic proposition has been strengthened and the field of operation has been expanded. Electromagnetic waves are extensively used as a veritably important natural resource, similar as in drug, diurnal life and service operations. In 1895, Russian scientist Popov constructed the first wireless telegraph system. In the same time, Wilhelm Roentgen discovered-ray. In 1914, voice communication came a reality. In 1920, marketable radio broadcasting began to be used. Radar was constructed in the 30s of the 20th centuries, and radar and energy information developed fleetly in the 40s. In the 50s, the first artificial satellite was put into the sky, and the satellite communication assiduity developed fleetly.

3.MAIN OPERATIONS OF ELECTROMAGNETIC WAVES.

3.1 Electromagnetic waves used in the field of life:

The main use cases of electromagnetic waves are in food and transportation. One of the most classic operations is microwave oven ranges, the core technology of which is microwave ovens generated by magnetrons that converts electrical energy into an electromagnetic field with centres of positive and negative charges that change direction billions of times a alternate. Inside each magnetron are two important isolation bodies, where a constant glamorous field is created that allows the electron circle emitted by the filament to fly and forms the external wall of the electron- displaced magnetron's metal dent to induce charge separation and voltage (2). Under the relation of the electric field and the glamorous field, microwave ovens are generated when electrons pass through the anode reverberate dent. Broilers in microwave oven ranges beget electrode atoms in food to vibrate at high frequentness, and utmost of the food is water atoms. Both the hydrogen and oxygen atoms of water atoms are charged, so water atoms bear as electric dipoles, and when microwave ovens are applied to water atoms, the water atoms begin to rotate due to the torque generated on the dipole. Microwave oven energy passing through a food product causes these dipolar atoms to vibrate. The performing internal friction produces heat.

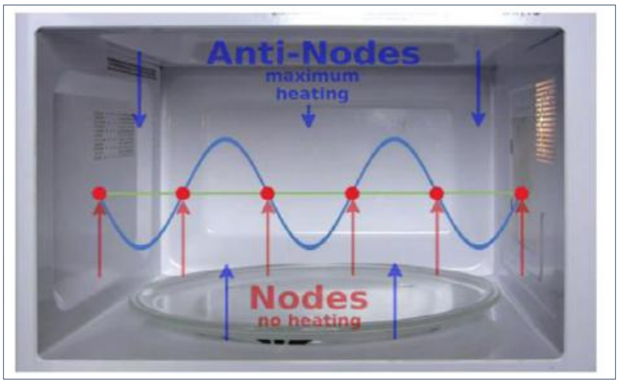

Figure 3. A microwave oven

Microwave ovens are more effective than traditional heating styles because microwave ovens can access food, causing further heat to oscillate with water atoms outside, and gradationally heat food from the inside, while traditional heating styles, on the negative, conduct heat from the outside to the inside. A microwave oven is shown in Fig. 3

Electromagnetic waves are substantially divided into two uses in food processing; one is for cooking, and the other is for disinfection. Infrared is substantially used in the former- food processing and cooking. Compared with traditional processing styles, the infrared wavelength is longer, the capability to access objects is stronger, and energy can directly access the inside of the reused food, so that the outside and outdoors are unevenly hotted, reducing the loss of nutrients caused by inordinate heating. Meanwhile, it can ameliorate energy effectiveness. Processes like deliquescing frozen foods, as well as fried foods and ignited foods can also be answered using infrared heating. Ultraviolet rays are substantially used to disinfect food. Its wavelength has a veritably egregious inhibitory effect on bacteria, and there's no adverse effect on food whether it's the disinfection of the food itself or the processing environment (6).

In addition, electromagnetic waves are also extensively used in the field of communication, and people generally use the network to gain information. The way of information transmission is generally to make an analogy signal at the information end, and also convert it into an electrical signal through modulation, which is the process of altering a specific of a carrier wave to correspond with an information signal, or modulating wave. Once transmitted over a channel, the modulated signal is also reused through demodulation to recover the original information- bearing signal. The purpose of which is to reduce the length of the antenna to reduce the cost and realize the multiplexing of the antenna and the anti-interference capability of the modulated signal. Also, in multitudinous telecommunications systems, it's essential to use a waveform to directly transfer an information bearing signal through a transmission medium. This is completed by modulation (7).

The introductory principle of satellite communication is to regard artificial earth satellites as information transfer stations to realize the reflection, propagation and metamorphosis of electromagnetic information work. Through the work done on the base of artificial earth satellites, electromagnetic information can be transmitted between satellites without interference, although communication satellites are located in different regions (8). The specific principle is as follows the antenna generates a signal and packets the signal to launch into space. Star link devices constantly control the wireless cluster, enabling it to point directly at satellites moving in the sky, and TV satellite dish uses parabolic mirrors to focus and admit satellite signals. Television satellite dish accepts television signals from space. Since satellite communication is actually microwave oven information transmission, communication satellite stations can transmit microwave oven information and need to cooperate with the transfer station to insure the completion of high- quality transportation and signal conversion work. A TV Satellite Dish is illustrated in Fig. 4.

Figure 4. TV Satellite Dish

The application of electromagnetic waves in the field of transportation is also popular. Common velocimeters work by using the Doppler Effect, that is, the phenomenon of changes in the frequency of electromagnetic waves. According to the Doppler Effect, when the car is close to a fixed speed measuring instrument

$$f_0 = \frac{\vartheta}{\vartheta - \vartheta_s} f$$

Where fo indicates the frequency at the velocimeter, v indicates the velocity of the wave, vs indicates the speed of the carrier emitting the sound source, represents the frequency of the sound source wave.

The frequency of electromagnetic waves received by the speed measuring instrument will become higher accordingly. When the car is far away from a fixed speed measuring instrument

$$f_0 = \frac{\vartheta}{\vartheta + \vartheta_s} f$$

The frequency of electromagnetic waves entered by the speed measuring instrument will come lower. By measuring the rate of change of frequency, we can reflect the speed of the auto. In this way, within a certain period of time, through the frequency change of the entered electromagnetic waves reflected by the auto, we can calculate the speed of the auto. Due to the fast transmission speed of electromagnetic waves and the small error, the use of electromagnetic waves for speed dimension calculus is veritably accurate (6). A marketplace velocimeter is shown in Fig. 5.

Figure 5. A traffic speedometer

3.2. Electromagnetic waves used in the military field:

Electromagnetic waves also have many applications of electromagnetic waves in the military field, first of all, infrared thermal imaging technology by detecting and analysing the infrared radiation energy distribution emitted by the surface of the object, to obtain the surface temperature, heat distribution and thermal characteristics of the object and other information. The radiant energy of the surface of the object is related to its absolute temperature, and any object with a temperature higher than absolute 0 degrees in reality radiates infrared energy, and the temperature difference information on the surface and inside the object is contained by the thermal radiation infrared rays of these objects with a temperature higher than -273 degrees [9]. Infrared sensors use detectors of infrared sensitive materials to sense the infrared radiation emitted by an object and convert it into an electrical signal. Thermal imaging systems convert the data acquired by the sensor into images and display them, requiring infrared cameras with high spatial resolution to capture richer information and post-process it to improve image quality. Infrared thermography enables accurate measurement and analysis of surface temperature and thermal characteristics without touching the object. In military applications, it mainly relies on capturing the infrared radiation emitted by the target to form a "thermal image" for inter-combat. Here is a picture in Fig.6. Showing the Herds under the infrared thermal imager.

Figure 6. Herd of elephants under infrared thermal imager

The crucial technology of electronic warfare can be divided into information sorting, radiation source identification technology interference strategy optimization technology, that is, after the information sorting is done, the radiation source identification and interference strategy selection are carried out succession ally, and signal sorting is the process of separating the pulsation train of each radiation source from the interleaved signal pulsation inflow, and farther opting the target signal. Radiation source identification technology can identify the working state and gets of the radiation source, the individual radiation source and the radiation source attributes. The state of the radiation source means that the radiation source is represented by a certain sequence of pulsations, and the parameter signals in the pulsation sequence conform to a certain modulation law, and the radiation source gets is a combination of working modes formed to achieve a special politic purpose, generally used in military search and following. Source affection identification is a system of relating the use of the radiation source, relating the type of emitting glamorous radiation source, and determining the trouble degree of the radiation source The identification of the individual radiation source is grounded on the unintentional modulation characteristics of the signal in the pulsation to determine the generation of the signal, for illustration, from the characteristics of the signal itself, the two signals may be the same, that is, two radiation sources of the same model. At this time, the radiation source can be directly determined by the individual identification technology of the radiation source, because different radiation source individuals have different circuit device structure technology, working temperature and environs, etc. The interference strategy of the radiation source can be divided into including interference pattern selection and interference waveform optimization, and the interference pattern Selection is grounded on the trouble perception of the target signal to establish the stylish correspondence

Between the being interference pattern and the target state, and also form an optimal set of interference strategy. The interference waveform optimization is to use its own being interference resources to stay for the occasion to do interference waveform optimization and use these coffers to singly induce new interference waveforms, which can form a better interference pattern to intrude.

The alternate is the infrared guided missile, which works on the principle of operation the infrared light of the target passes through the glass cover of the guidance head of the infrared guided missile, and the glass reflected to the middle through the hollow glass is again reflected into the lens group in the middle tube, and the focus of the infrared light falls on the lead sulphide photosensitive element, and the infrared signal it perceives is reused by the unit modulation disc amplitude modulation system, and the target becomes a bright spot for the infrared guided missile to carry out target chasing. An infrared guided missile is demonstrated in Fig. 7. (3).

Figure 7. IRIS-T infrared guided missile

3.3 Electromagnetic waves used in the medical field:

Conditions are ineluctable in the mortal body, so electromagnetic waves are frequently used in the examination and treatment of conditions (6). In 1895, a physicist named Wilhelm Conrad Roentgen accidentally stumbled upon X-rays while conducting experiments with a cathode- beam tube in his laboratory at Wurzburg University in Germany. The tube had positive and negative electrodes reprised as a bulb, and when applied to a high voltage, emitted a fluorescent green light. Despite taking precautions by shielding the tube with heavy black paper, Roentgen noticed green, fluorescent light being generated by a material just a many feet down from the tube. Grounded on this observation, he inferred that a new" beam" was being emitted from the tube and able of passing through indeed heavy black paper to excite phosphorescent materials in the room. Likewise, Roentgen discovered that these beams could access utmost solid objects, but not bones or essence. This unanticipated discovery marked a major advance in medical imaging, and its implications are still felt moment. X-ray technology enabled doctors to see inside the mortal body without invasive procedures, allowing for before and more accurate decisions.

Roentgen's pioneering work and posterior examination laid the foundation for the use of radiography in ultramodern remedy (10). His discovery also earned him the first Nobel Prize in Physics in 1901. But now that the principle behind this is known, when high- energy electrons hit metal material in the cathode tube, these high- energy electrons either reduce their velocity and release some redundant energy or knock these electrons out of the atom to initiate the electron combination and continue to release energy. But in either case, the energy is released in the form of X-rays, which hit electrons in the substance when they interact with other substances. Occasionally an X-ray transfers all of his energy to other matter and is absorbed by that substance, but occasionally it transfers only a portion of the energy, and the rest is dispersed. The frequency of these two results depends on the number of electrons hit by the X-ray, and the tighter the structure of the substance or the advanced the electron number of the substance, the more likely collisions are being. The bones are thick and rich in calcium, that is, they've a advanced number of electrons. Thus, bones are more likely to absorb-rays, and other soft tissues, similar as muscles, are more fluently entered by X rays (different tissues in the mortal body absorb X-rays to different degrees). This is the utmost introductory principle of X-ray filming. Using the sensitivity of X-rays to light, darkness of different densities can be easily observed on the illumination screen. This system does not bear slit of mortal epidermal tissue, the operation is simple, the detriment to the mortal body is small, and the finding cost is low. Now it has come the main outfit for clinical opinion, especially orthopaedic opinion. An X- ray instrument is shown in Fig. 8.

Figure 8. Advanced X-ray medical instrument

Gamma rays are used in medicine to treat tumours and other conditions. Among them, Gamma Knife surgery is a type of radiotherapy therapy, and Gamma Knife is not a real knife. It uses 201 cobalt-60 radioactive sources to emit a single, high-dose beam focused on targets identified through advanced imaging techniques and dose planning computer systems. In the target range, 201 beams of focused radiation produce a lethal amount to irradiate tumour cells and destroy the lesion at one time without damaging the surrounding normal tissues. Compared with conventional radiotherapy, gamma knife has less impact on surrounding tissues, effectively protects the optic nerve, reduces risk, and effectively reduces the recurrence rate of hypopituitarism [11]. Picture regarding gamma knife equipment put into use is shown in Fig.9.

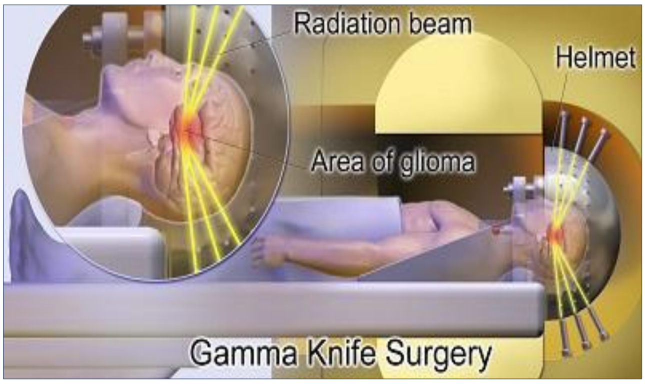

Figure9. Gamma Knife equipment

4. CONCLUSION:

This paper explains the physical concepts and principles of electromagnetic waves. Electromagnetic waves are oscillations caused by the interaction of electric and glamorous fields at the same speed as the speed of light. Electromagnetic waves can be divided into radio waves, microwave ovens, infrared, visible light, ultraviolet beams, X-rays and γ beams according to different frequencies. Next, this paper introduces the characteristics and operations of colourful electromagnetic waves microwave ovens are used in medical, military and diurnal life; Radio waves are extensively used in the messages and broadcasting industries; Infrared is used in remote controls, infrared guided missiles, thermal imagers, etc.; The visible band is used in lighting and display technology; Ultraviolet light should be used for disinfection and sterilization; X-ray for medical resolution; γ radiation is used in fields similar as medical imaging and radiation therapy.

Although electromagnetic waves have irreplaceable usages in life, military and medical treatment, there are still certain problems in the being electromagnetic wave technology. For example, in diurnal life, ultraviolet rays have certain implicit risks and fluently burn people's skin. Long- term exposure to ultraviolet rays can also beget problems similar as greensickness and shelling of the skin. In addition, infrared night vision aptitude also has military disadvantages, because they are fluently disturbed by heat sources similar as fires, making them ineffective. In microwave oven communication, still, the communication between the base station and the user terminal if the transmission distance is long. Involves the transmission of signals, and these signals are not directly transmitted, but refract, reflected, diffracted, scattered and transmitted in a variety of ways. Thus, the staffs needs to increase the number of microwave oven mounts, which will lead to a significant increase in costs and a drop in transmission effectiveness.

The most advanced technology for radio wave technology to transmit information today is 5G technology, but 6G will achieve 10 to 100 times faster speeds than 5G, and peak rates will reach hundreds or even tbps. In terms of network deployment and operational efficiency, we will support sustainable development and will improve the spectrum efficiency of 6G by 1.5 to 3 times, which is better than 5G. Intelligence, as a key capability of wireless communication networks, is becoming a technology that provides start-ups to enterprises. From 5G to 6G, artificial intelligence will complete the role transformation from auxiliary to endogenous. The fundamental design principle of wireless AI is to create an efficient and sustainable network of the future. We need to make efficient use of fragmented spectrum and improve energy efficiency. From 5G to 6G, artificial intelligence will complete the role transformation from auxiliary to endogenous. The fundamental design principle of wireless artificial intelligence is to create an efficient and sustainable network of the future. We need to make efficient use of fragmented spectrum and improve energy efficiency. In the future, the 6G spectrum will be extended to frequency bands with more abundant spectrum resources, such as terahertz and visible light. Larger bandwidth, higher frequency, and full-spectrum technologies have become an evolutionary trend. Mm Wave technology is already supported in the fifth generation of wireless communication systems (5G) standards. In the 6G era, millimetre wave technology will mature and be widely used. At
the same time, the exploration of terahertz frequency bands has become a hot topic in 6G research, millimetre wave and terahertz provide large bandwidth, forming a multi-frequency collaborative ubiquitous group grid bureau. Meanwhile, demand in the medical field will drive the development of X-ray and gamma rays in the future. In the military aspect, countries will develop telegraph devices, electronic components and weapon systems with high protection against electromagnetic hazards and establish corresponding identification equipment.

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