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A Review of Wireless Remote Control Techniques Types, Strictures and Applications

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Abstract: *Technological development has positively affected people's lives, and one of the most prominent of these technologies is wireless remote control (WRC) systems because of their wide use in various fields, especially domestic, industrial, military, medical, engineering and others. This article presents a complete review of the common and important types of wireless remote control technologies in terms of their component structure, design, and common applications. The review also includes the general concept, component structure, and study in details of each unit and its function within the system, and how the units are interconnected to form a complete wireless remote control system.*

Keyword: *Wireless remote control, Wi-Fi, Radio frequency (RF), infrared (IR), Bluetooth.*

1. INTRODUCTION

The first advantages of technological development are to reduce the effort and burden on the human being. This leads to an increase in the effectiveness of the human being and his ability to communicate and keep pace with the developments and innovations of devices, and as a final result, improving human life. One of the aforementioned devices is WRC. Wireless control is a concept called to an electronic technology that is usually used to operate another device from an unspecified distance without direct contact between the person and the device to be operated, or in short, a remote control device is defined as a device used to control another device from a distance or remotely [1,2].

In WRC technologies, communication or transmission of information is done via free space (air) using electromagnetic waves such as Wi-Fi, Radio frequency (RF), infrared (IR), Bluetooth, and so on, which guides the propagation from one point to another. The main feature that prefers wireless technologies over wireless is mobility. The very important part in remote control systems is the wireless communication system, and it is normal for any development in the techniques of this part lead to an evolution in control systems [3,4].

The first wireless TV remote control called Flashmatic was developed by Zenith Radio Corporation in 1950 [5,6]. From the first discovery of remote control technology in the field of television control until 1977, it was based on ultrasonic tones technology, but today it uses commonly consumer infrared(CIR) devices technology.

In the past radio waves are used as a technology for various remote control applications. This technology employs the electromagnetic waves to transmitted execute commands, and also use low frequency radio transmitter battery operated remote control for consumer [7,8]. One of the major and wide applications in homes remote controls is infrared (IR) light technology [9,10]. The IR technology relies on the use of infrared rays to control devices by sending signals to control multiple functions of the devices [11].

One reference refers to the design of a wireless remote control to control multiple functions of a spy camera and a listening device. The work of the device includes controlling the movement and rotation of the spy camera in several directions clockwise and counterclockwise, in addition to controlling the process of turning ON and OFF the spy listening device to record the human voice without his knowledge. All this is done through a wireless remote control mechanism based on Dual Tone Multi-Frequency (DTMF) technology [12]. Using the user's phone number during a call, and based on DTMF technology, multiple electrical devices are controlled wirelessly and remotely, so that it is possible to turn ON and OFF any device individually [13,14].

As a result of the widespread reliance on cellular communication technology to exchange information and as a result of its spread in almost all countries of the world, this technology has been relied upon in extensive and important uses in the field of wireless remote control, for example in applications that include homes automation and engineering such as monitoring and protection devices, security, warning, industrial, medical and others [15-19].

In this work, a comprehensive review was conducted on the various types of wireless remote control. The study includes access to the working mecha-

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nism of each type, its component units, as well as its common applications at the present time. The topic also included the mechanism of operation, extinguishing, sending and receiving, as well as obstacles or limitations of use, if any.

2. GENERAL CONCEPT OF WRC

In general, the simplified concept of remote control devices is, a person exercises the control mechanism on an electrical device without direct contact between the person and the device. The simplest type of control is to turn off and turn on the device. Other matters of control depend on the nature of the device, for example in the TV. In addition to turning off and on, controlling the volume (increasing or decreasing) change channels, color, searching and so on. As a comprehensive concept, the operation of WRC is implemented through a group of components. The main components of a WRC system as shows in a block diagram of Figure 1.

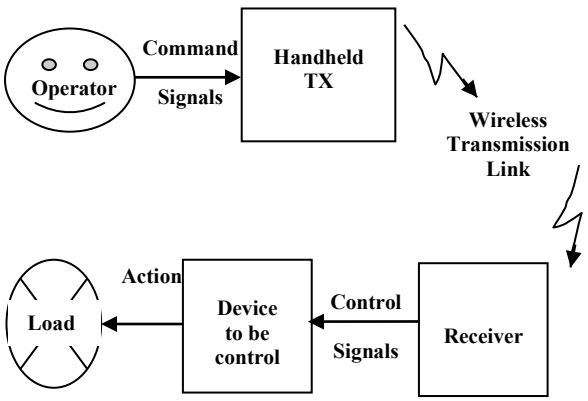

Figure 1 General structure of WRC system

2.1 Operator and Handheld Transmitter

The operator is the source for issuing command signals through a hand-held transmitter, and therefore it is the starting point for the work of the wireless remote control system. The encrypted commands issued by the transmitter, as shown in the Figure 1, are sent to the receiver unit of the system via a wireless transmission medium

2.2 Wireless Transmission link

It is the carrier medium or the means or tools by which electromagnetic signals (infrared, visible light, radio, Wi-Fi, Bluetooth, GSM network) are transmitted in space wirelessly from the transmitting unit to the receiving unit. The distance between sent and received units depends on the type of remote control technology.

2.3 Receiver

The type of receiver and the concept or mechanism of its work differs from one device to another. This difference depends on the used remote control device technology, but of course and in general, the work of the receiver unit is the opposite of the work of the transmitter unit. The main function of this unit is to convert the code signal received through the transmission medium into an electrical signal that is transmitted to the relevant device.

3. COMMON TYPE OF WRC

In this part of the review article, the common types of wireless remote control systems are covered in detail, and the components, features, and applications of each system are identified.

3.1 Wi-Fi

Technology used for connecting electronics devices in a wireless local area network (WLAN) defined as WiFi technology. This technology operates in the unlicensed bands, which frequencies of 2.4 GHz and 5 GHz for the standards family (IEEE802.11). WiFi allows to achieve very fast data rates up to 54 Mb/s or even more because has a massive bandwidth [20,21]. The advantages of WiFi are as follows:

1. It covers a wide area and has a long effective distance. The communication distance in the open area is up to 305m, and the communication distance in the closed area is 76-122m. It can be applied not only to the local rooms but also to the entire buildings.
2. Transmission speed is very fast, up to 54 Mbps. In addition to the low cost, it has low power consumption, in line with the modern "green low-carbon" appeal.

According to the research, the WiFi signal belongs to a kind of microwave and has little impact on the human body. The impact of the radiation generated by Wi-Fi on the human body is negligible within a safe range. However, since WiFi uses RF technology, air is used as a medium to transmit and receive data, signals that transmitted through radio waves are easily disturbed by external environments, and the security is not high, so they are not suitable for smart home control systems that require high security [22].

3.2 Bluetooth Technology

Bluetooth is standardized as IEEE 802.15.1 standard, used in generally for short range communication. It works on 2.4 to 2.485 GHz frequency of the ISM band having 79 channels separated by 1 MHz. Data transmission is done in the form of packets, which are transmitted by Frequency Hopping Spread Spectrum (FHSS). It consumes very less power, available at very economical price, and it is a very simple yet effective technology (Rajeev & Brent, 2000).

The function of Bluetooth wireless technology is

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to permits a wireless connection to many electronic devices over short distances for the purpose of data transferring [23]. On the other word Bluetooth is a very exciting low energy wireless technology for the Internet of Things (IoT) [24]. One of the application, the Bluetooth technology used to control the home appliances with an employing Arduino board and a series of programming codes applied to it that will make the electric appliance to turn ON and OFF. This process without direct contact or human intervention in the operation or extinguishing of electrical appliances [25-28]. Bluetooth being employed in new applications, such as Healthcare, security, fitness and many more. Sometimes, Bluetooth Technology encounters with pairing error, yet it still has a very wide range of application, such as wireless networking between devices and other wireless peripherals such as mouse, keyboard, headsets, media transfer, wireless control, Data logging equipment, and many more [29] Figure 2. explain the architecture of the Bluetooth network.

Figure 2 Architectures of the Bluetooth network

3.3 Radio Technology

Radio control technology (RCT) is one that uses radio signals as a tool for remote control of equipment [30]. Radio frequency remote control it can be operated without affected by the line of sight, transmits signal with a wider range than infrared (IR) or Bluetooth, and is not sensitive to light, like infrared technology [31]. RF remote controller's technology is widely used in the construction, manufacturing, and transportation industries. Miners drill, and cranes, among others, are commonly equipped with radio controllers for flexible operation. In industrial environments, this represents significant important, as a result of the work environment and critical conditions and the great risks inherent in it [32].

3.3.1 Factors that determine the range of RF

There are four main factors that determine the range of radio frequency

1. Transmission power.
2. Receiver sensitivity.
3. Antenna gain factor.
4. Attenuation of the radio signal.

Wide common type of RF technology is the RF module as shown in Figure 3 which is transmitter/receiver (Tx/Rx) pair operates at a frequency of 433 MHz. The transmitters is STT- 433 MHz with 12-bits encoder parallel data type HT12E, and RF Receiver STR-433MHz with 12-bits decoder type HT12D [33].

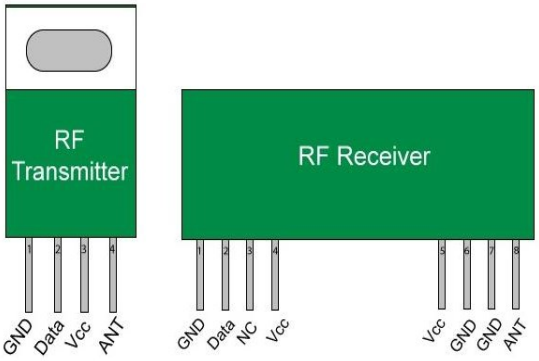

Figure 3 RF module

3.3.2 RF module Applications

There are very wide uses for this model in RF wireless applications, and some of them can be mentioned as follows [34]:

1. 1. Wireless home security systems.
   2. RF contactless smart cards.
   3. Access control systems.
   4. Wireless fire protection systems.
   5. Robot remote control.
   6. Industrial remote control, telemetry and remote sensing.
   7. Remote control for various types of household appliances and electronics projects
   8. Area paging.
   9. Vehicle monitoring.
   10. Telemetry.
   11. Wireless data transmissions.

3.4 INFRARED IR

Infrared (IR) is one of the wireless technology used for communication the devices over short ranges about 1 to 10 meters. It provides data rates about 4 Mbps. The basic operation mechanism of IR technol-

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ogy it uses invisible infrared light that corresponds to specific binary codes that represent commands [35]. This infrared ray is used to transmit signals from the remote control to the device it controls. Typical infrared frequencies used by infrared remote controls are: 36KHz, 38KHz, to 56KHz, and 455KHz. Figure 4 shows the block diagram of IR system.

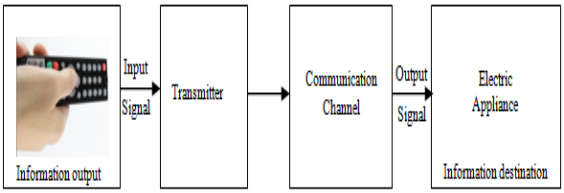

Figure 4 IR system block diagram

The IR technology has major limitations because it has a short transmission range, requires line of sight (direct pointed between the handheld transmitter and the receiver), and is unable to penetrate walls [36]. One of the IR protocol, called as Sony SIRC protocol. This protocol appears in three versions, 12, 15, and 20 bits [37]. The details divided and features of these versions are as follows:

- For 12-bit version, is divided into, 7 bits as a command bit, and 5 bits as address bits.
- For 15-bit version, divided into, 7 bits as a command bit, and 8 bits as address bits.
- For 20-bit version, divided into 7 bits as a command bit, 5 bits as address bits, and 8 bits as extended bits.
- The SIRC protocol depends on Pulse width modulation.
- Required carrier frequency of 40KHz.
- Bit time of 1.2ms or 0.6ms.

The pulse width encoding of the bits is used for the SIRC protocol. The pulse representing a logical "0" is 0.6ms long. While the logical "1" is a 1.2ms long burst of the 40KHz carrier. The length space interval separated of all types of bursts is 0.6ms. The recommended carrier duty-cycle is 1/4 or 1/3. All the above details are shown in Figure 5.

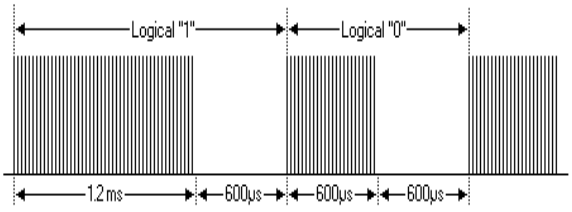

Figure 5 Modulation used for Sony SIRC protocol

For 12-bit SIRC protocol, LSB is first transmitted. The wide of the start burst is 2.4ms, then followed by 0.6ms standard space. The SIRC message specify a part from signaling as start burst that used to adjust the gain of the IR receiver, then transmitted 7-bit command, followed by the 5-bit address. Figure 6 showing details the pulse train of 12-bit SIRC protocol.

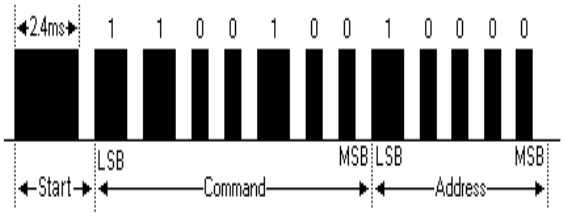

Figure 6 Pulse train of 12 bit SIRC protocol

One of the practical applications using infrared technology is its use in designing remote control of Intelligent Digital Calendar. This system uses infrared remote control with LED luminous digital display day, time, date, solar terms countdown, a digital chip control internal data operation [38]. IR technology features include, very low power consuming, very economical, highly secure, portable, immune from noise yet contains simple circuitry. It is usually used in TV remote control and cheap mobile handsets; Figure 7 explain an example of IR application.

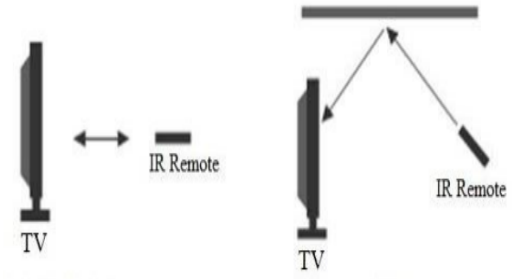

Figure 7 IR used for TV control

Advantech's of IR remote control

- The IR technology is low cost as compared to other remote control technologies.
- Much longer battery life for an IR remote control compare to other technology like RF or Wi-Fi.
- No licensing fee is required.

3.5 ZigBee

In some workplaces, we need applications that do not require high data transmission and require low power consumption, such as industrial applications or hospitals. Therefore, ZigBee technology is the alternative to Wi-Fi and Bluetooth technologies. Zigbee is suitable when communication is occasional, smaller

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packet sizes are used, and power consumption is an issue [39].

Zigbee works on radio standards and 2.4 GHz, 900 MHz, 868 MHz unlicensed band frequency. Due to low power and low data rate its range is limited from 10 to 100m. Its having data rate of 250kbps. Due to energy efficiency, it provides long battery life [40,41].

Zigbee is it supports 65000 nodes in network topology. It provides various network topologies like point to point, point to multipoint, mesh network topology and "Personal Area Network" (PAN). It provides security and application services which can work on PHY layer and MAC layer [42]. Zigbee technology is very much safe and secure, because it provides 128-bit encryption method to get security from data collision, interference, and trespassing. Zigbee is used in various applications such as automation, Automatic meter reading, sensor networking in industrial, Medical devices and applications, lighting control, building automation and many more thanks to a very low cost and long battery life.

Applications of ZigBee Technology

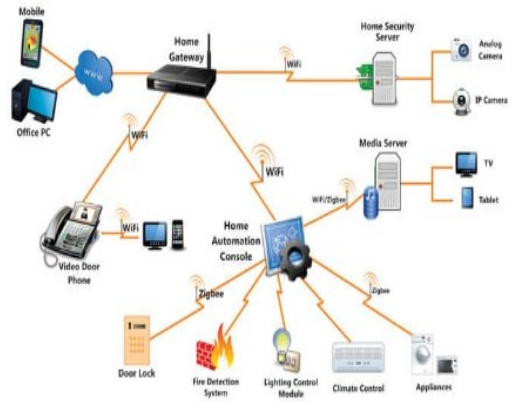

Figure 8: ZigBee Home Automation

Home Automation: ZigBee technology proves to be the most reliable technology in realizing home automation. home automation it is simply the automated control of various electronic devices at your home Figure 8. These devices are often connected to the Internet, making them able to be remotely controlled. With home automation, smart devices can easily trigger each other, thus making you free from the hassle of controlling them manually through a remote app or even just by speaking to them. With home automation, you can now play music or even watch TV series that you have been waiting to watch. This is achieved with the help of smart home devices such as smart speakers, smart TV, game consoles, etc. Thus, you can now have total control over your home security system, lights, and other devices with just a few presses on your remote control.

Different applications like controlling and monitoring energy consumption, water management, light control etc. have been made easier through automation using ZigBee technology.

4. COMPARISON BETWEEN WRC TYPES

In this section, we compare the common types of wireless remote control technologies. The comparison includes identifying the ranges that each technology can cover, the type of coverage, working frequencies, data transfer rate and power consumption, as shown in Table 1. Through comparison, there is complete clarity about the specifications of each technology and the possibility of its use or the conditions in which it can be used. We also get to know the operating frequencies and this avoids us from using them in places that contain a jamming system or interference or avoiding places that use devices operating at the same frequencies. Also, knowing the choice of technology depending on the extent or type of coverage is a very important factor. For example, the technology required to control systems or devices in different places, and the presence of cement blocks or buildings, differs from the technology used for devices located in one room or place, and so on.

TABLE 1: COMPARISON OF COMMON TYPES OF WRC

TN	CR	OP	TR	TD	PC
BT	10 m	2.4 to 2.485 GHz	1 Mbps	All Dir.	Medium
RF	100 m	433.92 MHz	1 to 10 kbps	All Dir.	Low
Wi-Fi	100 m	2.4 to 5 GHz	11 Mbps	All Dir.	High
IR	1–10m	875 nm	1.152 Mbps	Line of site	Low
ZB	10–100m	2.4 GHz, 886 MHz and 900MHz	250 kbps	Line of site	Very Low

Where Technology Name = TN
Coverage Range = CR
Operation Frequency = OF
Transfer Rate = TR
Transfer Direction = TD
Power Consumption = PC
Bluetooth =BT
ZigBee = ZB

5. WIRELESS TECHNOLOGY IN MANUFACURING

Different aspects must be considered, when considering the introduction of wireless technology into manufacturing [43]:

1. Costs: The first and prime reason justifying wireless deployment is always substantial cost

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saving due to wire replacement; the industrial case is particularly critical due to the high cost of industrial wiring.

2. Resiliency and Safety: The impact of a link failure event over system safety must be minimized: wireless is vulnerable to noise, temporary interferences, fading. A receiver can be ―jammed‖ quite easily. Usually, these are the first objections to wireless: there are several possible solutions preventing such problems and, wires can be cut (and hard to repair) and wired devices (switches, hubs, repeaters) are prone to malfunction!
3. Priority: Safety requirements involve the use of a protocol which is reliable and offers real time guarantees for the most important signals. Not all the protocols confirm to this criterion. Consider a simplistic safe approach which interrupts processes whenever messages get lost, this may lead to many interruptions reducing your process efficiency and throughput.
4. Security: Another threat concerns vulnerability of wireless under stringent conditions. A number of solutions exist or are in progress to improve the privacy and security of wireless transmissions.
5. Mobility: Wireless means mobility. Freedom from wires brings several benefits: you can move around your plant without disrupting connectivity; in case of frequent reconfiguration of your plant involving assembly lines, you do not have to deal with cable bonds. In most cases, an industrial application requires free nomadic approach than a true mobile solution: this means that you work in quasi-static scenarios on which wireless is particularly effective.
6. Scalability: Intuitively, a wireless solution is more efficient if it allows for an increase in the number of users connected to the same device (overcoming the paradigm of a point-to-point connection), number of active networks, and capability to automatically configure.
7. Protocols Inter operation: Several different industrial communication standards compete and cannot inter-work with each other. A wireless protocol can behave as a bridging protocol among them.
8. Fabric-to-Office Integration: A wireless protocol can efficiently transport office-related and internet-oriented traffic. This would allow to carry on the evolution started by industrial Ethernet, network maintenance costs optimization and always on connection to the office. The integration with the office (the so-called global networking‖) enables new perspective, in value added industrial management (automated asset management, supply chain management, customer relationship management).

6. ACTIVE APPLICATIONS OF WRC

In general, there are effective applications for using wireless remote control. These applications are included in different fields such as military, industrial, medical, civil, and so on, so that some of these applications have a significant impact on people's lives or have a significant impact on the belief of institutions such as the use of drones in modern wars and what has a significant impact on the military belief of states. In this paragraph, a group of these applications will be addressed.

The use of wirelessly controlled military robots to spy on the enemy and gather information. In the military field, remote control technology can be used to target the enemy like a model of a military robot in the shape of a tank Enhanced detection, control and tracking of objects using Android to simulate shooting at a hostile target [44]. One of the important and effective applications in the field of wireless remote control is unmanned aerial vehicles (UAV) or drones, and over time they have been used in different ways and applications. These aircraft differ in terms of height, speed, flight time, load size, and applications, as some are armed offensive aircraft, others for espionage purposes, others for securing communications, and so on. [45,46].

One important medical application is the use of wireless remote-control robots as assistants to automate the transfer of patient supplies to treat enemy transmission in infectious diseases such as COVID-19. Remote wireless communication is necessary to control such type of robots [47].

7. CONCLUSION

This review article, adopted a comprehensive study of the general types of remote control systems in terms of coverage, installation, and uses. The reason for this, in recent days, the use of wireless technologies has been resorted to instead of wires, for several reasons, including: Mobility, infrastructure, where the installation of infrastructure is a time-consuming and expensive task for wired communication systems, while the task is simple and less expensive for wireless communications. In addition, in case of implement emergency situations and in remote areas, it is not an easy task to set up a wired communication system, but it is possible to set up a wireless communication system. Also, there are many reasons for relying on the use of wireless communications, including large and world coverage, freedom from wires, flexibility and staying in contact. For the above-mentioned important reasons, the reliance on remote control technologies has become increasingly dependent on wireless systems instead of wired communications technologies.

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