Overview of Microwave and Infrared Transmission Systems for Short Distance Network Connections

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***Abstract*: This paper evaluates the advantages of both microwave and infrared technology and examines some crucial issues where each technology provides added value. Both Microwave and Infrared transmission systems are use for short distance network connections. They need line-of-sight and have its merits and demerits. The evaluation of the two transmission systems were in the areas of frequency spectrum, bandwidth, technical issues, confidentiality, security issues, distance coverage etc. From the research, it was found that when frequency spectrum licensing is difficult and expensive to obtain, infrared transmission systems have a good advantage, and infrared transmission system is less inclined to be intercepted. Microwave transmission systems are advantageous in areas that are foggy and are extensively use when distance is less than four (4) miles.**

Keywords-* Microwaves, Infrared, Technology, Transmission, Network

I. INTRODUCTION

One of the most critical issues in telecommunication is short distance connectivity. The two technologies that provide cost effective limited distance connectivity in telecommunication are microwave and infrared communication links. Microwave transmission refers to the technology of transmitting information or energy by the use of radio waves whose wavelengths are conveniently measured in small numbers of centimetre. This part of the radio spectrum ranges across frequencies of roughly 1.0 gigahertz (GHz) to 30 GHz, which correspond to wavelengths from 30 centimeters down to 1.0 cm. Infrared (IR) is electromagnetic radiation with longer wavelengths than those of visible light, extending from the nominal red edge of the visible spectrum at 700 nanometers (nm) to 1 mm. This range of wavelengths corresponds to a frequency range of approximately 430 THz down to 300 GHz[1]. Most of the thermal radiation emitted by objects near room temperature is infrared. Both microwave and infrared communication systems utilize wireless technologies and therefore do not require the laying of a physical cable [2].Microwaves are widely used for point-to-point communications because their small wavelength allows conveniently-sized antennas to direct them in narrow beams, which can be pointed directly at the receiving antenna. This allows nearby microwave equipment to use the same frequencies without interfering with each other, as lower frequency radio waves do. Another advantage is that the high frequency of microwaves gives the microwave band a very large information-carrying capacity; the microwave band has a bandwidth 30 times that of all the rest of the radio spectrum below it. Properties of microwave Involve line of sight (LOS) communication technology, Affected greatly by environmental constraints, including rain fade, Have very limited penetration capabilities through obstacles such as hills, buildings and trees, Sensitive to high pollen count, Signals can be degraded during Solar proton events[3]. Uses of microwave include; in communications between satellites and base stations, as backbone carriers for cellular systems, In short range indoor communications, Telecommunications, in linking remote and regional telephone exchanges to larger (main) exchanges without the need for copper/optical fibre lines. Infrared light signals cannot pass through walls, which reduces reception to the room in which the transmitter is installed. Transmission is reliable and absolutely free of the interference caused by electromagnetic fields or structural elements in the building, such as metal reinforcements. Infrared transmission systems can be used easily in many different countries; an obligation to register them, similar to the allocation of radio licenses, is not required Infrared radiation can be used to remotely determine the temperature of objects (if the emissivity is known). This is termed thermography, or in the case of very hot objects in the NIR or visible it is termed pyrometry. Thermography (thermal imaging) is mainly used in military and industrial applications but the technology is reaching the public market in the form of infrared cameras on cars due to the massively reduced production costs. Non-military uses of Infrared radiation include thermal efficiency analysis, environmental monitoring, industrial facility inspections, remote temperature sensing, short-ranged wireless communication, spectroscopy, and weather forecasting. It is critical to understand the technical issues and components of microwave and infrared technology to understand the advantages of both. In many cases, microwave and infrared systems operate with equal effectiveness and the choice of system will be determined based on business factors (such as equipment delivery time). Both systems cannot be easily tapped and therefore are perceived to be much more secure. Microwave systems requires specific frequency spectrum, while infrared transmission systems do not require acquisition of any frequency spectrum.

II BACKGROUND INFORMATION

Microwave systems were first demonstrated in 1933 with a transmission across the English Channel [4]. Beginning in the 1940s, networks of microwave relay links, such as the AT&T Long Lines system in the U.S., carried long distance telephone calls and television programs between cities. The first system dubbed TD-2 and built by AT&T, connected New York and Boston in 1947 with a series of eight radio relay stations [5]. These included long daisy-chained series of such links that traversed mountain ranges and spanned continents. By the 1970's, most televisions shows, telegrams, and domestic long distance telephone calls were transported on microwave links [6]. Much of the transcontinental traffic is now carried by cheaper optical fibers and communication satellites, but microwave relay remains important for shorter distances.

William Herschel, an astronomer, discovered Infrared radiation [7]. He published his results in 1800 before the Royal Society of London. Herschel used a prism to refract light from the sun and detected the infrared, beyond the red part of the spectrum, through an increase in the temperature recorded on a thermometer. He was surprised at the result and called them "Calorific Rays".

Alexander Graham Bell was the first to transmit a human voice over a light beam in 1880 [8]. The term 'Infrared' appeared late in the 19th century [9, 10]. Light beam communications has gradually shifted with improvements in technology from visible light to Infrared.

III METHODOLOGY

Figure1 and 2 shows the diagrams of microwave and infrared transmission systems. The assessment of the two transmission technologies is based on technical issues, frequency spectrum, cost, disruption, distance, confidentiality, security issues and bandwidth.

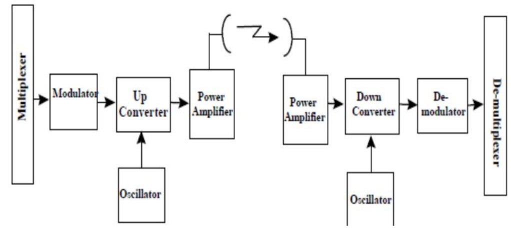

Fig-1: Microwave transmission system

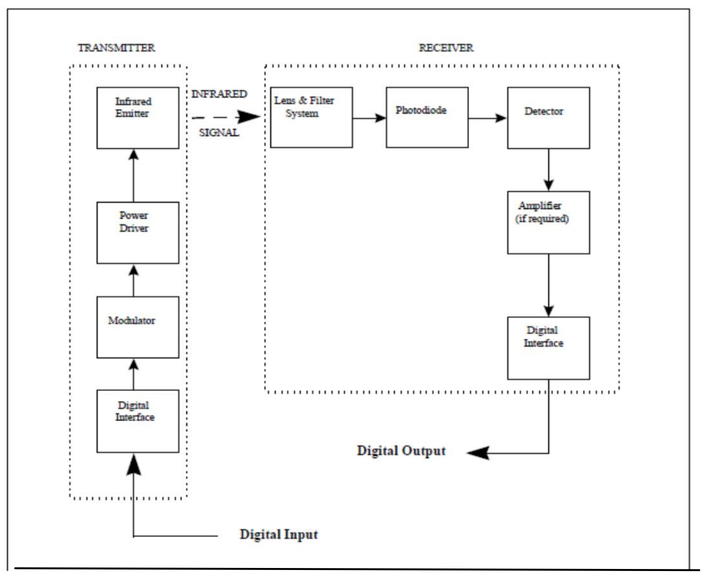

Fig-2: Infrared transmission system

A. Spectrum

Figure 3 below shows the electromagnetic wavelength and frequency spectrum of microwave and infrared transmission systems. The transmission of infrared occurs at higher frequencies than microwave and as the transmission of the carrier frequency increases, its waves become more directional. Therefore infrared signal propagation is much more directional than microwave.

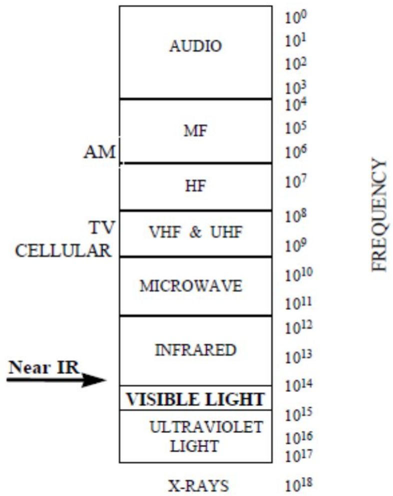

Fig-3: The Electromagnetic Spectrum [10]

B. *Bandwidth and Distance*

It is easier to provide higher bandwidth at high carrier frequencies. Since infrared has a higher frequency than microwave, it has the ability to provide higher bandwidths. The power of an infrared emitter is very low in comparison to that of a microwave transmitter. Therefore distance is a limiting factor in infrared

C. Technical Issues

Line-of-sight is critical for the operation of microwave transmission systems because microwave beams will not penetrate objects. This line-of-sight path is not just a narrow sight path, but must be wide enough to provide a Fresnel Zone Clearance. This zone describes the area around the beam's center line where penetrating objects will cause wave reflections that will cancel out most or all of the beam's power at the receiver end. The worst place for penetration into this critical area around the beam is halfway between the transmitter and the receiver.

D. Disruptions

Due to the "line-of-sight" requirement of both infrared and microwave communication, disruptions to these systems cause serious problems for users. If obstructions are even temporary, such as airplane, the signals of both systems will be interrupted. Most disruptions for infrared and microwave transmission systems are caused by atmospheric conditions or other types of interference which are more predictable. The two major atmospheric effects are scattering and shimmer.

E. Security Issues

Both microwave and infrared transmission systems can be affected if the receiving antenna is violated due to tampering, vandalism, or other modification created to deter or avert proper reception. Microwave transmission has an effective cone of reception of about 10 degrees outward from the transmission antenna. At a distance of 5,000 feet, this would create a reception zone of almost 900 feet in diameter. An infrared laser system at the same distance would produce a beam of only three to five feet. Microwave signals can be intercepted without the user's knowledge and even by spy satellites. Infrared systems have an inherent advantage. Not only because of the narrow beam width but their signals cannot be detected by satellites. Also interception requires a break in the signal which could be detected and investigated for immediate resolution.

F. *Installation and Maintenance Issues*

In installing of infrared and microwave transmission systems we put into consideration line-of-sight and the quality of the transmitter and receiver or antenna mountings. Due to the strong directionality produced by lasers, light can be sent accurately to receivers placed close together.

Microwave antennas do not have the small footprint capability of infrared transmission systems and therefore require greater distances between receiving antennas facing the same direction. The mean time between failures (MTBF) for both infrared and microwave transmission systems is substantial. This makes them highly reliable from a maintenance perspective. There is no technical advantage regarding maintenance for either microwave or infrared transmission systems.

I. Cost

Due to technological advances, the cost for microwave and infrared transmission systems has decreased in recent years. Currently the cost of short distance microwave and infrared transmission systems are similar. Therefore there are no advantages based on cost for using microwave technology or infrared technology.

IV. RESULTS ANALYSIS

The summarized key results arising from the comparison are shown in Table 1.

Table1: Comparison study between microwave and infrared transmissions

COMPARATIVE TOOL	MICROWAVE	INFRARED
Frequency	3 GHz to 300 GHz	300 GHz to 400 THz
Bandwidth	Average	Higher
Distance	Short distances < 4miles	Distances>4miles

Disruptions	Affected	Affected
SECURITY ISSUES	Adversely Affected	Rarely occurs
Technical Issues	Line-of -sight	Optical safety
Installation and Maintenance Issues	Highly reliable	Highly reliable
Cost	Minimal	Minimal
Confidentiality	Need to encrypt data	No need to encrypt data
Wavelength	1 mm to 100 mm	750 nm to 1 mm

V SUMMARY AND CONCLUSIONS

Microwave and infrared transmission systems are alternatives for installation of short distance network connections. From the result in Table 1, it is evident to say that Infrared transmission system have some edge over microwave transmission as manifested in bandwidth, distance coverage, confidentiality and security.

Also the presence of high amounts of electromagnetic interference (EMI) suggested the use of infrared systems rather than microwave.

Therefore, from the above points discussed we can conclude that infrared is a better choice of transmission for short distance network connections.

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Biography

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