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ITU-APT Foundation of India

PROPOSED FURTHER MODIFICATIONS TO THE WORKING DOCUMENT TOWARDS A PRELIMINARY DRAFT NEW APT REPORT ON TERAHERTZ (THZ) FIXED WIRELESS SYSTEMS OPERATING IN THE FREQUENCY ABOVE 450 GHZ

1. Introduction:

AWG-30 has started work on a new Report on "Terahertz (THz) Fixed Wireless Systems Operating in the Frequency Above 450 GHz". The AWG-30 meeting developed a working document for the new report in AWG-30/TMP-02 for further drafting process.

2. Proposal:

IAFI through this contribution, provides additional inputs to the working document towards a new APT Report on "Terahertz (THz) Fixed Wireless Systems Operating in the Frequency Above 450 GHz" for consideration in upcoming AWG-31 meeting to address the emerging technologies and use-cases in Terahertz (THz) band. The THz band is expected to address new use-cases that include high-speed internet access; usage for industrial, societal and enterprise; and private networks. The THz band Fixed wireless systems can operate in several different frequency bands, depending on the application and the regulatory environment.

An updated working document is enclosed for further drafting.

Attachment 1:

Contact: Name
Organization, Country

Email:

ATTACHMENT 1

Task Group on Fixed Wireless and Ground-Based Radar Systems

WORKING DOCUMENT TOWARDS A PRELIMINARY DRAFT NEW APT REPORT ON TERAHERTZ (THZ) FIXED WIRELESS SYSTEMS OPERATING IN THE FREQUENCY ABOVE 450 GHZ

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[Editor's note: The text in this working document is developed using input contributions (AWG-30/INP-16, xxx, yyy,]

1. Introduction

Fixed Wireless Systems refer to communication systems that use wireless transmission to connect two fixed points or locations without requiring physical cables or wires. The term "fixed" refers to the fact that the system is set up in a fixed location, rather than being portable or mobile. Fixed wireless systems can be used for a variety of applications, including broadband internet access, point-to-point data transmission, video surveillance, etc.

The frequency range between 450 GHz and 1 000 GHz is the main part of Terahertz band, where Fixed Wireless Systems likely to operate in future. These systems use high-frequency electromagnetic waves to transmit information wirelessly between two points. The main reason for using these high carrier frequencies is that the availability of large contiguous bandwidth compared to previous wireless technologies, even capable of fitting state-of-the-art optical channels.

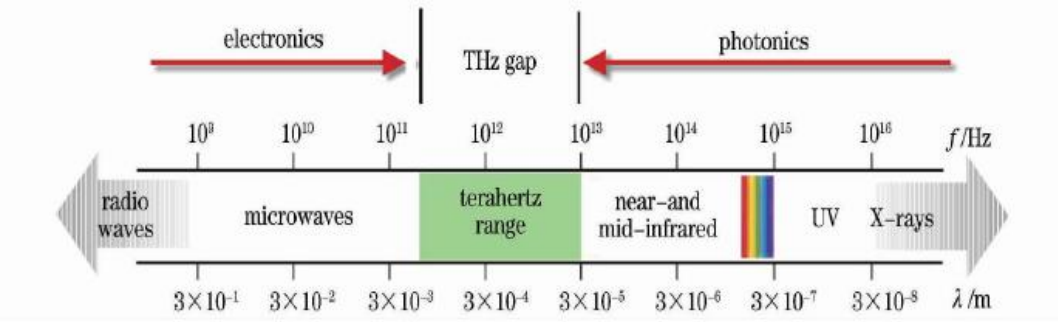

Figure 1 – Position of THZ waves in the electromagnetic spectrum

THz wireless systems offer the potential for extremely high data transfer rates, up to several terabits per second and low latency communication. In addition to this, Terahertz waves have the ability to penetrate through many materials that are opaque to visible and infrared light, such as plastics and clothing, and can be used for imaging applications in medicine, security screening, and industrial inspection. Similarly, Terahertz waves can be used for sensing and monitoring applications, such as detecting hidden weapons or explosives, and monitoring the moisture content in crops and soil.

However, THz frequencies are highly susceptible to atmospheric absorption and attenuation, which can limit their range and reliability. This makes it challenging to develop THz wireless systems for use in practical applications. Despite these challenges, frequencies above 300 GHz offer some advantages, such as the availability of larger frequency bands, which can enable higher data rates and greater capacity for communication systems. These frequencies are also used in remote sensing applications such as atmospheric monitoring, environmental sensing, and imaging, where the atmospheric attenuation and scattering properties can be exploited for specific applications.

For a long time, THz spectrum was described as the last virgin land of the radio spectrum. Only a few scientific and astronomical services are deployed in these frequency bands, especially in bands above 450 GHz. In recent years, terahertz frequency band, has attracted a great deal of interest among various types of users due to their potential for use in a wide range of future technologies.

THz frequency band shows a great deal of promise for building the next generation of wireless technology. THz wireless systems offer the potential for extremely high data transfer rates, up to several terabits per second and low latency communication. Discussions are now gaining momentum with ecosystem partners including chip manufacturer, software and hardware vendors to manufacturer Fixed Wireless Access device in Terahertz frequency band. Many administrations are pursuing with international bodies for opening up more spectrum across all bands, including sub-mm-Wave band (THz band).

In addition to use for communication, Terahertz waves, due to their inherent propagation characteristics, can be used for a variety of applications, from communications to defense, security, space-exploration and medical imaging etc.

2. Scope

This report addresses the technological developments in THz band for fixed wireless access applications.

3. References

[1] APT Report No. APT/AWG/REP-66 (REV-1) of Sept, 2018 regarding short range Radiocommunication system operating in frequency range 275-1 000 GHz (report attached for reference).

[2] Report ITU-R SM.2350-1, Technology trends of active services in the frequency range 275-3 000 GHz (Question ITU-R 237/1)

[3] First input contribution on how to use of Terahertz frequency band for fixed wireless service, was submitted by the Japan in AWG-30 vide document No. AWG-30/IMP-16 for study at TG FWS/GBRS in the APT Wireless Group (contribution attached).

[4] IEEE 802.15 working group for Wireless Specialty Networks (WSN), which are used in IoT, wearables and autonomous vehicles.

4. Abbreviations and acronyms

FWA	Fixed Wireless Access
GHz	Gigahertz
RR	ITU Radio Regulations
mmWave	Millimeter-wave
THZ	Terahertz
UHDTV	Ultra-high-definition TV

5. Propagation characteristics in the frequency above 275 GHz

[Note: The following text will be further improved at the next meeting.]

AWG has developed APT Report on short range radiocommunication systems and application scenarios operating in the frequency range 275 - 1 000 GHz (APT/AWG/REP-66(Rev.1)) and this Report estimated available contiguous bands in the frequency range 100-1 000 GHz, as

shown in Table 1 and Figure 1. Those bands with attenuation losses by gasses of less than 100 dB/km are estimated by avoiding the specific resonant attenuation lines by oxygen and water vapour. Contiguous bandwidths over 50 GHz are achievable in the frequency ranges 200-320 GHz, 275-370 GHz, 380-445 GHz, 455-525 GHz, 625-725 GHz and 780-910 GHz, as shown in Table 1. The whole frequency band 200-320 GHz (1) cannot be used fixed services because the bands 200-209 GHz, 226-231.5 GHz, 235-238 GHz and 241-252 GHz are not allocated for fixed services in accordance with the Table of Frequency Allocations in Radio Regulations. The whole frequency band 275-370 GHz (4) cannot be used for fixed services because the frequency bands 296-306 GHz, 313-318 GHz and 333-356 GHz may only be used by fixed and land mobile service applications when specific conditions to ensure the protection of Earth exploration-satellite service (passive) applications are determined in accordance with RR No. **5.564A**. The whole frequency band 380-445 (5) can be used for fixed service applications because the frequency band 356-450 GHz is identified for those applications in accordance with RR No. **5.564A**. The other bands 455-525 GHz (6), 625-725 GHz (7) and 78-910 GHz (8) can provide the contiguous bandwidth over 70 GHz which is sufficient bandwidth to transmit data rates over 100 Gbit/s using a widely used QPSK modulation scheme.

Table 1

Estimation of frequency ranges and contiguous bandwidth provided by APT Report (APT/AWG/REP-66(Rev.1)).

No.	Frequency range (GHz)	Contiguous bandwidth (GHz)	Loss (dB/km)
(1)	200-320	120	< 10
(2)	275-320	45	< 10
(3)	335-360	25	< 10
(4)	275-370	95	< 100
(5)	380-445	65	< 100
(6)	455-525	70	< 100
(7)	625-725	100	< 100
(8)	780-910	130	< 100

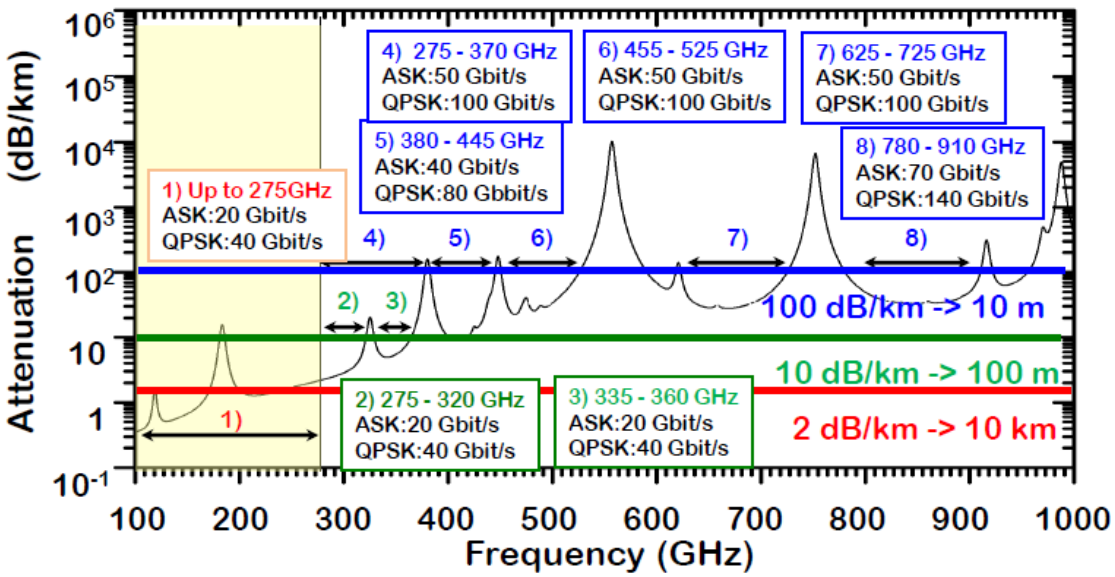

Figure 2

Attenuation characteristics and available contiguous bands in the frequency range from 100 GHz to 1000 GHz provided by APT Report (APT/AWG/REP-66(Rev.1)).

6. Typical use cases for Fixed Wireless Systems operating in the frequency range above 450 GHz

[Note: Each section will be further improved at the next meeting.]

6.1 Ultra-high-definition TV (UHDTV) Streaming

One of the important elements to determine system bandwidths are streaming data rates for video signals. Table 2 summarizes streaming data rates required for transmitting uncompressed or compressed ultra-high-definition TV signals (8K). It may be preferable to send uncompressed 8K video to avoid large latency, but the uncompressed 8K video requires ultra-high-speed data rates depending on video parameters, as shown in Table 2. Latency is determined from a tradeoff between streaming data rates and signal processing capabilities. As discussed in the first paragraph, THz spectrum provides sufficient bandwidths for transmitting uncompressed 8K video.

Table 2

Example of streaming data rate of uncompressed and compressed UHDTV.

Resolution	Frame frequency (Hz)	Multilevel gradation (bit)	Color depth (bit)	Streaming data rate (Gbit/s)	
				Uncompressed	H.265 (1/300)
7680 × 4320	120	12	36	144.0	0.48
	120	8	24	96.0	0.32
	60	8	24	48.0	0.16
	30	8	24	24.0	0.08

6.2 Factory monitoring system

THz fixed wireless systems have been studied for use of factory monitoring systems and train platform surveillance systems. Figure 2 illustrates factory monitoring systems where huge production items are move by crane trucks. The operator on the mobile operation station can produce items by looking at 8K monitor whose video is captured by 8K camera and sent through THz transceivers. Since the factory monitoring systems require high-resolution and low-latency video transfer from the floor to the truck, uncompressed 8K video may satisfy the requirements.

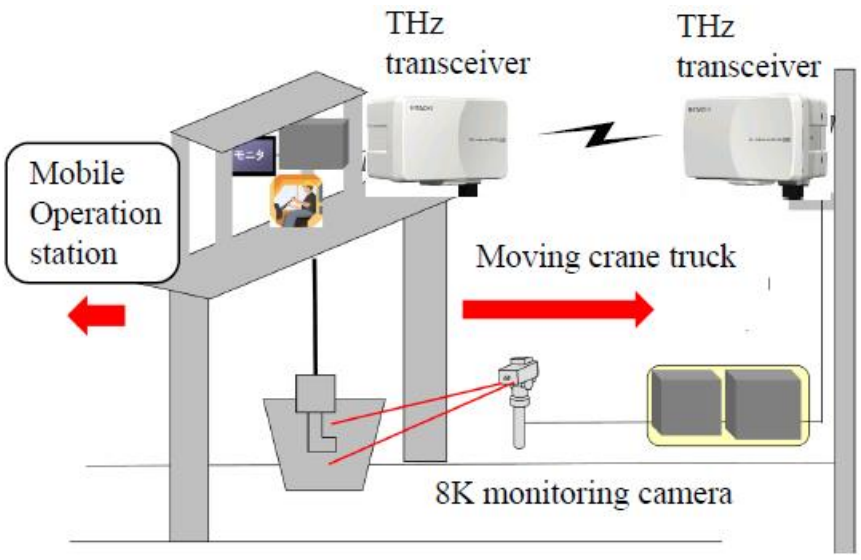

Figure 2
Factory monitoring system using THz transceivers.

6.3 Train platform surveillance system

The other application is shown in Figure 3 which illustrates train platform surveillance systems. The train platform surveillance system is widely introduced using 40 GHz and 60 GHz bands for safety operation of railway systems. However, in order to assist train crews to open/close train doors safely and keep passengers' movement on the platform under surveillance by looking at the monitor equipped in the train driver's room, high-resolution and low-latency video transfer from the platform to the driver's room is required. The uncompressed 8K video may satisfy the requirements and maintain passenger safety at the station.

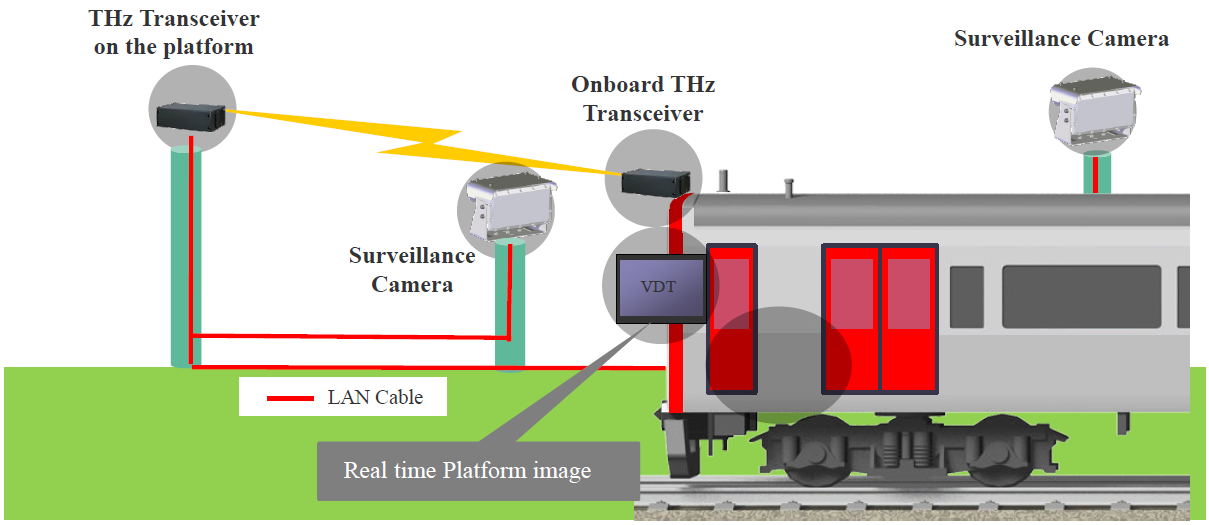

Figure 3
Train platform surveillance system using THz transceivers.

6.4 High resolution sensing

THz technologies are extremely promising for future wireless sensing systems, so emergence of new services that are beyond just communication. Shorter wavelengths imply smaller antennas, so small devices can be packed with tens or hundreds of antennas, which are beneficial for angle estimation. Ultra-fine beam generated by the ultra-large-scale antenna array can be implemented in the THz frequency band, which makes high-precision positioning and high-resolution sensing possible.

6.5 Medical imaging

THz signals, due to their characteristics, can penetrate materials and provide high resolution, without causing harm to human tissue. Microwaves are also penetrating but have low resolution, while X-ray radiation has higher resolution but may damage living tissues and DNA. Terahertz waves have the ability to penetrate through biological tissues without damaging them, making them ideal for medical imaging applications. Radio signal between 450 and 1000 GHz has a severe attenuation in water. This property can be used in medical field, as measuring the water content in tumor tissues which is significantly different from the normal tissue cells, so the cancer tissues can be located by analysing the tissue water content.

They can be used to detect early-stage skin cancer, as well as to study the structure and properties of other biological tissues, as not harmful to human beings, unlike high energy X-rays.

6.6 Security screening

THz waves can be used for security screening purposes, such as detecting concealed weapons or explosives. They can penetrate through most non-metallic materials, such as clothing or plastic, without posing any health risks to humans and with the help of the penetration loss value, detection of concealed weapon etc., is very easy using THz waves.

6.7 Material characterization

THz waves can be used to study the properties of various materials, such as semiconductors and polymers. This can be useful for developing new materials with specific properties, or for understanding the behavior of existing materials in different environments.

6.8 Support Future IMT-2030 Wireless communication fronthaul and backhaul needs.

The terahertz (THz) band (0.1–10 THz) is expected to be one of many promising pillar technologies that could be a good option for front-haul and back-haul connectivity needs of future IMT communication technologies, as it can facilitate extremely high-data-rate connection of the existing wireless transmission applications. THz communication technologies can facilitate extremely high-data-rate connection front-haul and back-haul by supporting several Gbit/s or even several Tbit/s, which is truly comparable to the connection experiences of optical fiber.

7. Technical and operational characteristics of THz systems in the frequency above 450 GHz

[Note: The following text will be further improved at the next meeting.]

An example of the frequency channel arrangement is shown in Figure 4 which utilizes the broad contiguous band obtained in the frequency above 450 GHz. The maximum channel bandwidth of 103.68 GHz could be arranged if THz frequency bands are applied for fixed wireless systems discussed above.

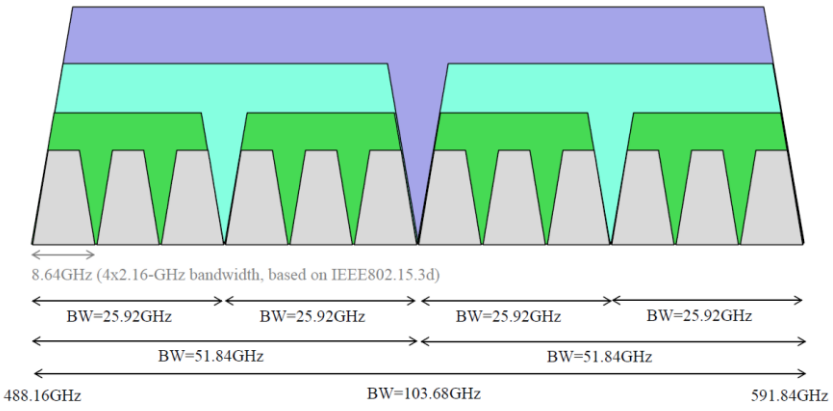

Figure 4
Example of frequency channel arrangement.

8. Summary

[TBD]