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| **United States of America** |
| Working document towards a preliminary draft new REPORT Itu-r Sm.[THZ\_SPEC] |
| **“Technical and operational characteristics of terrestrial terahertz spectroscopy/ISM and SRD applications of industry automation in shielded environments in the frequency range 71-275 GHz”** |

**Introduction**

There is growing interest in Extremely High Frequencies (EHF) in the 30-300 GHz frequency range for a technology is called alternatively “Terahertz Spectroscopy” (THzS). Several administrations have authorized this technology within their jurisdictions as ISM devices or short-range devices, but there are no ITU-R studies that provide the technical and operational characteristics for these types of devices.

This document proposes characteristics for THzS and reviews approaches to control its interferen~~ce~~ potential to allocated services including critical passive services.

**Proposal**

The United States of America proposes to begin developing a working document toward a preliminary draft new Report on Terrestrial Terahertz Spectroscopy for Industry Automation in Shielded Environments.

 **Attachment**: 1

WORKING DOCUMENT TOWARDS A PRELIMINARY
DRAFT NEW REPORT ITU-R SM.[THZ\_SPEC]

# **“Technical and Operational** **characteristics of terrestrial terahertz spectroscopy/ISM and SRD applications of industry automation in shielded environments in the frequency range 71-275 GHz”**

# 1 Introduction

There is a growing need to provide short range, indoor, sensing for industrial and professional application for measuring different physical parameters like presence, distance, velocity or material properties of a target object. The obtained information can be further processed and used for industrial automation and real time nondestructive quality control purposes in a wide variety of manufacturing operations to improve the quality and yield of products. This technology was used to provide safety critical data on space vehicles.

Several administrations have already permitted use of this technology within their jurisdictions, and it has been authorized in some administrations as an Industrial Scientific and Medical (ISM) application under the terms of **15.13** and in other administrations as a short-range device (SRD) although it is not harmonized as yet in Recommendation ITU-R SM.1896-1.

# 2 Related ITU Recommendations

[ITU-R P.676-13](https://www.itu.int/rec/R-REC-P.676/en) Attenuation by atmospheric gases and related effects

[ITU-R P.2109-2](https://www.itu.int/rec/R-REC-P.2109/en) Prediction of building entry loss

[ITU-R SM.1896-1](https://www.itu.int/dms_pubrec/itu-r/rec/sm/R-REC-SM.1896-1-201809-I%21%21PDF-E.pdf)  Frequency ranges for global or regional harmonization of short-range devices

# 3 Abbreviations and acronyms

THzS: Terahertz spectroscopy

# 4 ISM and SRD applications

[Editor’s Note: Possible liaising activity with SG3 Working Parties may be needed with regards to the propagation characteristics needed for BEL above 100 GHz]

THzS has a wide variety of applications in industrial operations but none in consumer products. Uses generally include industrial process monitoring and control; non-destructive imaging; and research and development spectroscopy. It has been used for industrial online factory process monitoring and control by measuring parameters such as multilayer thickness of extruded plastics; multilayer thicknesses of paints (including wet paint); basis weight; density; delamination and moisture.

It could be used in factories that make tires, rubber, building products, paper, plastic pipe, coated steel pipe, blow molded bottles, aircraft coatings, fuel tanks, and many other products.

As a nondestructive imaging device THzS has been used to image space craft external tanks, protection systems of spacecraft, aircraft coatings, ship coatings, radomes, food, pharmaceuticals, and other products.

All of the applications above are intrinsically indoor uses and involve transmission paths between the transmitter and the object being observed of less than 10 cm. The potential of such signals causing harmful interference to other radio services is decreased by propagation loss which in addition to the usual free space loss includes the attenuation by atmospheric gases described by Recommendation ITU-R P.676-13 (08/2022) and the building entry loss described by Recommendation ITU-R P.2109-2 (8/2023) although the model in the latter recommendation covers up to only 100 GHz. Some administrations have authorized the use of this technology as ISM devices and some have authorized it as SRD.

# 5 System Characteristics

There are two basic technologies that can be used in this application. Impulsive/time domain signals and FM/CW signals. In the impulsive/time domain approach a picosecond duration pulse is generated and connected with a very broadband antenna directional antenna. This results in a radiating signal with high directionally and bandwidths exceeding 100 GHz. Basic parameters are given below.

[Editor’s note: These Characteristics may be further developed, as appropriate, at future meetings. Membership is invited to submit information regarding characteristics of THz Spectroscopy systems.]

TABLE 1

Main parameters of impulsive/time domain terahertz spectroscopy
industry automation in shielded environments

|  |  |  |
| --- | --- | --- |
| Parameter | Value | Notes |
| Modulation Scheme | Impulsive time domain signal |  |
| Operating frequency range | 71 GHz – 6 THz |  |
| Modulation bandwidth | 50 GHz - 6THz |  |
| Pulse Repetition rate | 80-120 MHz |  |
| Duty Cycle | < 10-3 |  |
| Average power |  < 10 μW |  |
| Distance to Target | < 1 m |  |

Note: Impulsive ultrawideband-like emissions used in this type of THzS have no center frequency or modulation bandwidth in the normal sense of the terms used in **Appendix 1** of the Radio Regulations. In **Appendix 1** (Rev.WRC-19) Classification of Emissions, the best match for “basic characteristics/ First symbol– Type of modulation of the main carrier” would be “Sequence of unmodulated pulses - P”. The spectral shape of the emissions is determined by the physical characteristics of the transmitter and its antenna.

Alternatively, signals can be generated with a non-pulsed CW signal with monotonically changing frequency. While such signals have different ability to take measurements than the impulsive/time domain signal they also have the ability to transmit at varying powers over different bands that have different allocation, Thus, they can have lower output power in bands that have more complex harmful interference vulnerabilities. Basic parameters are given below.

TABLE 2

Main parameters frequency modulated carrier wave
terahertz spectroscopy industry automation in shielded environments

|  |  |  |
| --- | --- | --- |
| Parameter | Value | Notes |
| Modulation scheme | e.g. frequency modulated continuous wave (FMCW) or pulse-based modulation schemes | Combination of different OFRs possible |
| Operating frequency range (OFR) | 116−130 GHz134−141 GHz174.8−182 GHz185−190 GHz231.5−250 GHz |  |
| Available modulation bandwidth | 14 GHz, 7 GHz, 7.2 GHz, 5 GHz, 18.5 GHz |  |
| Used modulation bandwidth | up to 14 GHzup to 7 GHzup to 7.2 GHzup to 5 GHzup to18.5 GHz | -20 dB bandwidth |
| Sweeptime | 10 µs to 5 ms | for a single frequency sweep over entire modulation bandwidth |
| Duty cycle | ≤ 5% |  |
| Conducted peak carrier power | up to -5 dBm | Maximum peak output power at antenna feeding point |
| Conducted mean power | -18 dBm | with 5% duty cycle and −5 dBm peak carrier power |
| Conducted mean power spectral density  | -59.8 dBm/MHz | with 15 GHz modulation bandwidth and −18 dBm mean power |
| Maximum mean power spectral density (e.i.r.p.) | -23.8 dBm/MHz | calculated with 36 dBi maximum antenna gain |

# 6 Regional/National Experience on the deployment and operation of THzS devices

[Editor’s Note: Administrations are invited to provide more input on how this technology is implemented in their jurisdictions]

[TBD]