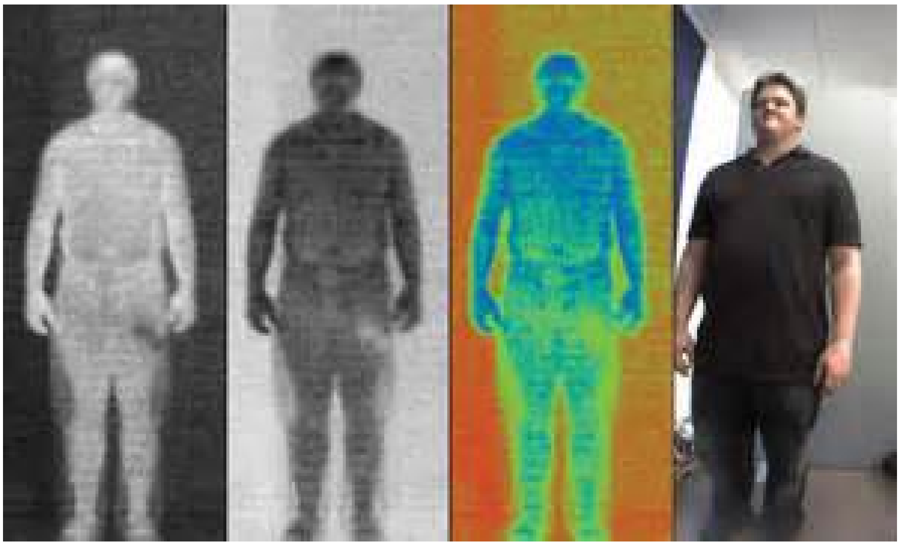
Transport, Security and Central Service Division

Technical Study on Whole Body Scanner



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1. Introduction

Whole Body Scanner

A **whole-body scanner** is a device for detecting objects on a person's body in order to security screening purposes without physically removing clothes or making physical contact. It depends on the specific technology so the operator may see an alternate-wavelength image of the person's naked body, or merely a cartoon-like representation of the person with an indicator showing where any suspicious items were detected. For privacy and security reasons, the display is generally not visible to other passengers, and in some cases is located in a separate room where the operator cannot see the face of the person being screened.

2. Physical characteristics of X-rays, Millimetre Waves and Tetra-hertz Waves

X-rays are electromagnetic radiations that have a wavelength in the range of 0.01 to 10 nanometers. Their frequencies lie between 30 petahertz and 30 exahertz (3×10^{16} Hz and 3×10^{19} Hz), corresponding to energies in the range of 120eV to 120keV. X-rays are classified as soft X-rays and hard X rays according to their penetrating powers. The penetrating abilities of X-rays depend on the energies they carry. X-rays of 120 eV to 10 keV are soft X-rays while those of 10 keV to 120 keV are hard X-rays. Soft X-rays hardly penetrate matters but hard X-rays can penetrate some solids and liquids so it is widely used for diagnostic radiography

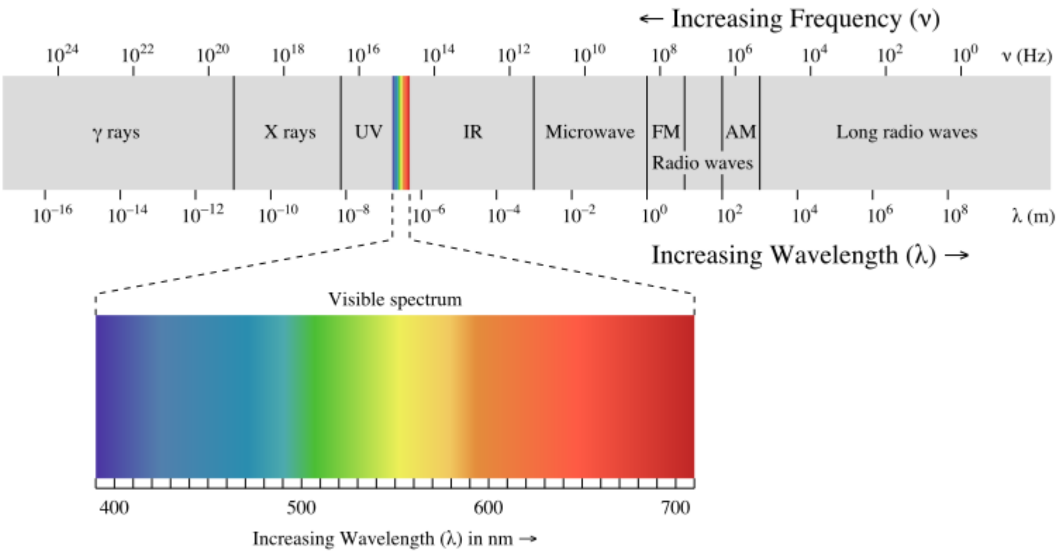

Fig. 1 Spectrum of Electromagnetic Wave

Extremely high frequency (EHF) is the ITU designation for the band of radio frequencies in the electromagnetic spectrum from 30 to 300 gigahertz, above which electromagnetic radiation is considered to be low (or far) infrared light, also referred to as terahertz radiation. Radio waves in this band have wavelengths from ten to one millimetre, giving it the name millimetre band or millimetre wave, sometimes abbreviated MMW or mmW.

Terahertz radiation – also known as submillimeter radiation, terahertz waves, tremendously high frequency, consists of electromagnetic waves within the ITU-designated band of frequencies from 0.3 to 3 terahertz (THz; 1 THz = 1012 Hz). Wavelengths of radiation in the terahertz band correspondingly range from 1 mm to 0.1 mm (or 100 μm). Terahertz radiation begins at a wavelength of one millimeter and proceeds into shorter wavelengths.

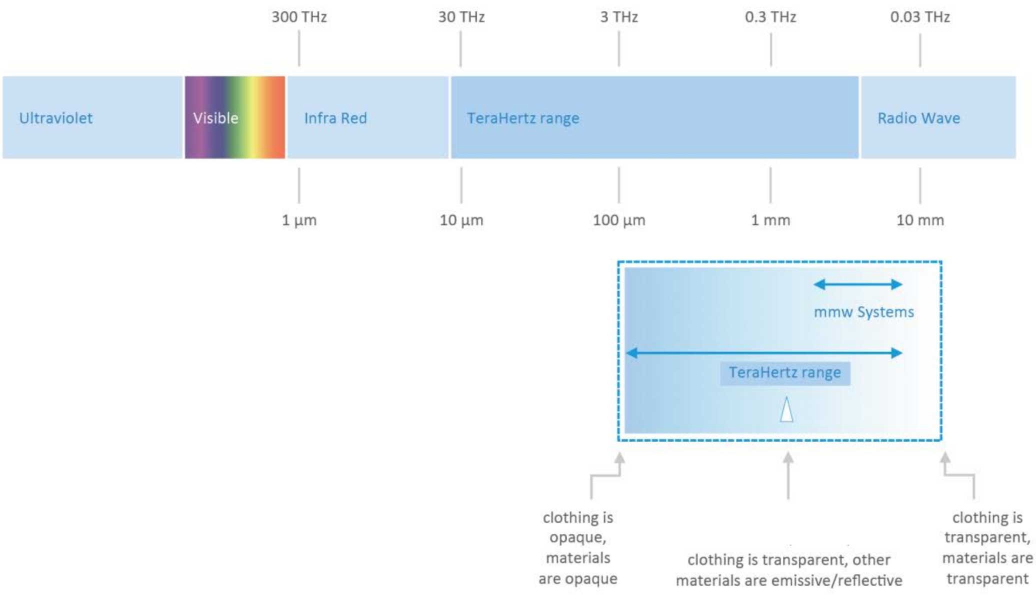

Fig. 2 Spectrum of Millimetre Wave and TeraHertz Wave

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3. Imaging Techniques

3.1 Active screening solutions

Transmission and Backscatter X-ray scanners and active millimeter wave scanners are used in people screening.

3.1.1 Transmission and Backscatter X-ray scanners

Traditional X-ray machines produce an image based on variation in transmission of X-rays via a target but backscatter X-ray scanners detect the radiation reflected by a target. Backscatter X-rays interact in accordance with the physical characteristics of the material being scanned when a target is radiated. Scanners then interpret these interactions and imaging software produces a detailed, high contract 2-D image of the target, with brighter areas denoting materials of high reflectivity.

Fig. 3 Transmission X-ray Scanner and image

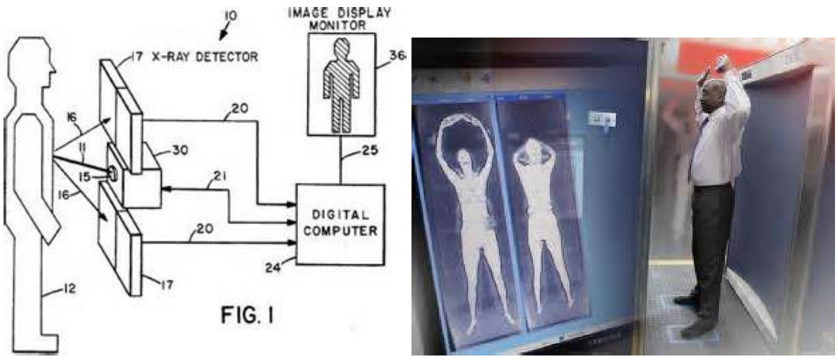


Fig. 4 Principle of Backscatter X-ray and the image formed

3.1.2 Active millimetre wave (mmW) scanners

Similar to backscatter X-ray scanners, active millimetre wave scanners radiate a target and highlight any concealed objects based on reflected radiation. However, instead of X-rays, these scanners use millimetre (30-100GHz) frequencies so some consider safer than X-rays.

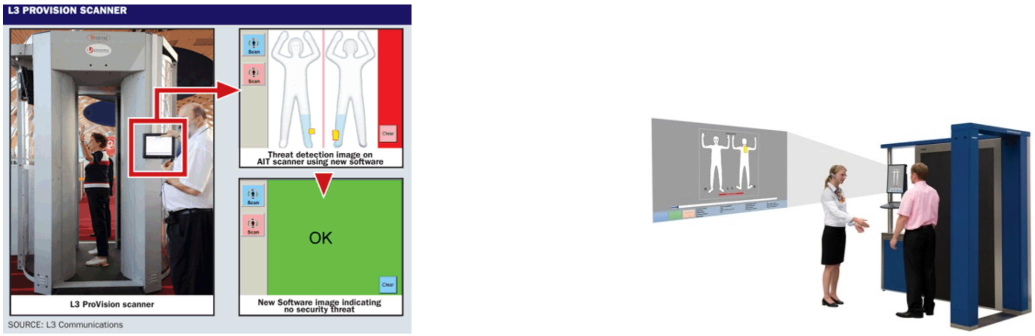


Fig.5 Active Millimetre Wave Scanner and Image

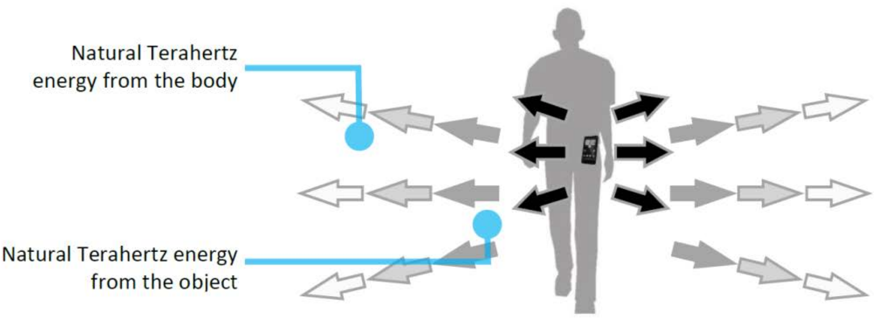
3.2 Passive screening solutions

Passive TetraHertz and millimetre wave scanners simply receive the energy emitted naturally by humans, objects and their surrounding environment. This helps mitigate many of the criticisms leveled at the perceived safety of active scanners, although misconception do remain.

3.2.1 Passive TetraHertz wave scanners

The term 'Terahertz' refers to a form of natural thermal (heat) energy that is emitted (released) in differing amounts by every person and object.

The scanner measures the difference in the Terahertz energy released by people and objects in order to detect concealments.



Key principles of TeraHertz image based detection

Deployment environment: All images require appropriate contrast in order to ensure the images can be easily interpreted. For example, when using an optical camera if the sun is in the background it can be difficult to see details within the image.

The scanner requires contrast between the person and the background so it is advised that the deployment location is air conditioned to ensure that there is a temperature difference between the person and the background.

Emission: All objects emit some Terahertz energy. The amount of Terahertz energy emitted by non-metal objects is related to the objects temperature. Metal objects emit very little Terahertz.

Reflection: Every object can reflect Terahertz but metal objects reflect a lot of energy. It is therefore also advised that the scanner is operated within an air conditioned environment to ensure that concealed metal objects reflect their cooler surroundings.

Transmission: Some materials including clothing allow a lot of Terahertz energy to pass through them. Each layer of clothing will block a small amount of energy.

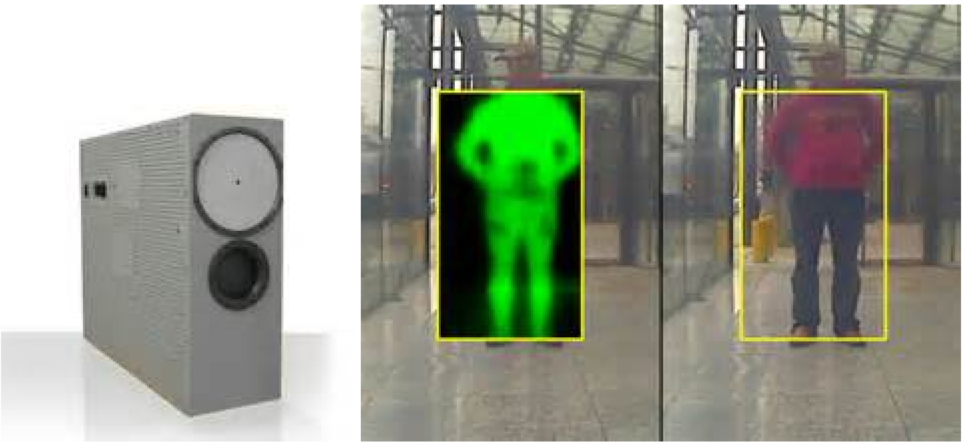


Fig.6 Passive TetraHertz wave scanner and Image

3.2.2 Passive Millimetre wave scanners

Similar to passive TetraHertz wave scanners, these scanners use millimetre (30-100GHz) frequencies.

Fig.7 Passive Millimetre Wave Scanner and Image

3.3 Comparison and Analysis on different technologies

Transmission and Backscatter X-rays represent a form of ionizing radiation that may pose significant health risks if not adequately controlled. Millimetre wave scanners use non-ionizing radiation and are typically considered as safe. However, concerns have been raised that no long-term studies have been conducted – and public opposition to the use of active radiation in any unfamiliar technology is inevitable, until questions of safety been independently addressed.

Active systems currently in use vary in weight between 500 -1000kg and impose a substantial footprint. They are therefore unlikely to integrate easily into existing security infrastructure or locations where space is limited, without significant installation effort. Owing to their size and weight, these systems cannot be considered portable and cannot be deployed quickly to new locations at short notice.

Depending on system, throughput is limited to around 3-5 persons per minute, making screening of large numbers in busy environments virtually impossible. Some screening procedures even require a series of poses to produce an adequate image of a person – decreasing throughput still further. Particularly during busy periods, this may reduce the frequency of use and result in security vulnerabilities.

Due to scale and limited detection range of these scanners, they cannot be used in a cover manner or for screening multiple people whilst on the move. Further, many of these systems attract problematic legal questions and additional permissions may be required for their use.

Active technologies can be costly to acquire, maintain and operate. These systems may also incur significant energy costs and require multiple operators if privacy concerns dictate an operator of the same gender. The lifetime cost of these products is therefore anticipated to be very high. In some cases, the associated operating costs may even exceed the capital cost of purchasing the product.

Millimetre wave systems (to 100GHz) are vulnerable to environmental changes and are less effective if exposed to any illumination or sunlight. At millimetre wave frequencies, some materials (and therefore concealed objects) may appear transparent, making it difficult to detect them reliably. For example, plastic explosives may appear translucent at these frequencies, resulting in security vulnerabilities as these objects go undetected. The human body is highly reflective at millimetre wave frequencies. This means that the human form reflects any local environment (imagine a person covered in silver paint). This can lead to many false positive detections – that require invasive, time-consuming and personnel-intensive pat down searches that increase costs and reduce throughput of people.

For a constant resolution at a fixed distance, TetraHertz wave passive detection system will be considerably smaller than a system using a lower frequency – and therefore a lower frequency system would have to be much larger so as to achieve the same resolution at the same distance.

In comparison to other passive people screening systems TetraHertz wave scanners are less susceptible to the effects of environmental illumination.

With its small and lightweight form factor, as well as its resilience to environmental conditions, TetraHertz wave units can be deployed as a standalone screening solution – or incorporated into wider security architectures.

The telescopic optics in the scanner provide a large depth of field enabling continuous imaging between approximately 3 m and 10m. This allows for screening of an individual or multiple people whilst on the move and is therefore effective at maintaining levels of throughput.

In addition, the ability to form images of people at various distance gives operators more time to examine a subject over a greater distance and elapsed time. A large depth of field also allows for covert deployment in environments where discretion, rather than deterrence, is the priority.

The fact that TetraHertz wave are high frequency and short wavelength gives rise to some defining benefits in the detection of concealed objects. Materials that are associated with typical concealed threats (plastic explosive in particular) appear much more clearly at TeraHertz frequencies than would be the case at the millimetre wave frequencies (30-100GHz) that are typically used by other passive scanning systems.

3.4 Summary

Technology	Active Radiation	Distance to Target	Typical Weight	Covert use	Speed of Screening	Image Resolution	System/Setup Relocation	Environment Condition	Market Price (HKD)
Transmission	Yes	0.5m	600 to 1000 kg	No	Low	High	Difficult	No	2M
Backscatter X-ray									3 to 4 M
Active Millimetre	Yes	0.5m	400 to 800 kg	No	Low	Medium	Difficult	Air Condition Required	3 to 4 M
Passive Millimetre	No	3-5m	35 to 45kg	Yes	High	Low	Easy	Air Condition Required	2M
Passive TeraHertz	No	3-15m	20 to 25kg	Yes	High	Low	Easy	Air Condition Required	2 to 3 M

Table 1. Comparison of people screening measures

3.5 Comparison between different bands

Advanced feature	OD Security	AS&E	Digital Barrier	Microsemi	Millivision	L-3 Communications	Smiths Detection
Transmission x-ray	Y(H)	N	N	N	N	N	Y
Backscatter X-ray	N	Y	N	N	N	N	N
Active Millimetre Wave	N	N	N	N	N	Y	Y
Passive Millimetre Wave	N	N	N	Y	Y	N	N
Passive Tera-Hertz Wave	N	N	Y(H)	N	N	N	N

Symbols: Y: Available

H: Applied to Hong Kong

Table 2 Comparison of feature on different brands

4. Application of the whole body scanner

- Passenger screening (e.g. contraband detection)
- Checkpoint screening for concealed threats
- Visitor screening for high-profile sites and VIPS
- Employee screening for commercial loss prevention

5. Applications in Hong Kong

For high security issue, the transmission X-ray has already been used in Correctional Services Department. For public health and privacy reasons, the passive Tetra-Hertz wave scanner was exploited for C&ED at Hong Kong International Airport and two scanners will be installed soon at Lok Ma Chau Spurline Control Point.

6. Conclusion

By comparison, the passive Tetra-Hertz wave scanner can provide a safe, high-throughput, portable, overt or covert solution for standoff detection of medium to large object such as metals, plastics, ceramics, liquids, gels and powders. So it can be quickly and easily incorporated into existing operational settings and environments where space is limited. They are also suitable in situations where people are compliant, semi-compliant or non-compliant.

7. Reference materials

[1] http://www.as-e.com

[2] http://www.microsemi.com/document-portal/doc_view/132516-gen2

[3] http://www.millivision.com/System-X350.html

[4] http://www.millivision.com/portal-350.html

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[6] http://en.wikipedia.org/wiki/X-ray#Compton_scattering

[7] http://en.wikipedia.org/wiki/Backscatter_X-ray

[8] http://en.wikipedia.org/wiki/X-ray

[9] http://www.odsecurity.nl

[10] http://www.sds.l-3com.com/advancedimaging/provision-at.htm

[11] http://www.smithsdetection.com/index.php/people-screening-systems.html