Microwave System for Secret Remote Inspection of Persons (MS-SRIP)

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ABSTRACT

A device for standoff detection of metallic and non-metallic objects concealed under clothing on human body is described. The device, which is based on active interrogation with gigahertz-range electromagnetic waves, can perform secret inspection of moving targets. It provides both the image of concealed objects and their dielectric characteristics, which can be used to facilitate detection of plastic explosives.

Keywords: *explosives, standoff, microwaves, gigahertz, dielectric properties.*

1.0 INTRODUCTION

Electromagnetic (EM) waves with frequencies in the range of tens of gigahertz may be primary candidates for standoff detection of explosives concealed under clothing on human body for the following reasons:

- They have high-enough penetrating ability in wet environments (unlike terahertz-range EM waves), enough to penetrate tens of meters of humid air and layers of wet clothing.
- They do not require bulky portals, delicate aiming devices etc., so the potential "suicide bomber" is not aware of the fact that he is inspected.
- All the required components (sources, receivers, electronic components) are cheap and readily available.

Very low power of the EM waves emitted as a discrete set of narrow frequency lines makes the technique completely safe for human health and for electrical appliances. Image resolution of ~1 cm can be achieved, which, though less than that of terahertz or x-ray systems, is enough to recognize the concealed threat, while not presenting privacy problems.

Kuznetsov, A.; Evsenin, A. (2007) Microwave System for Secret Remote Inspection of Persons (MS-SRIP). In *Prediction and Detection of Improvised Explosive Devices (IED)* (pp. 23-1 – 23-6). Meeting Proceedings RTO-MP-SET-117, Paper 23. Neuilly-sur-Seine, France: RTO. Available from: http://www.rto.nato.int.

The proposed Microwave System for Secret Remote Inspection of People (MS-SRIP, Figure 1) is based on active probing with microwaves. The system is intended for real-time detection of metallic and dielectric objects hidden under clothes on body of a moving person.

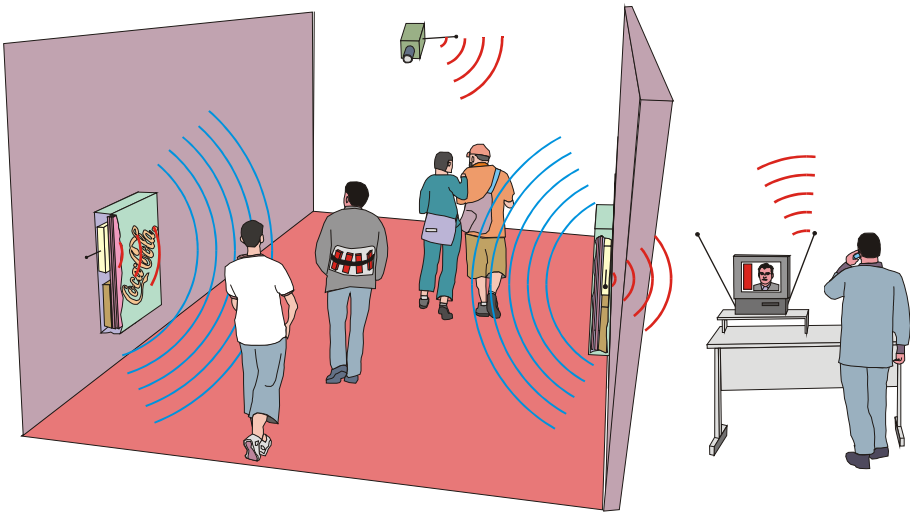


Figure 1. Example of the MS-SRIP installation in a corridor.

2.0 EXPERIMENTAL RESULTS WITH THE PROTOTYPE

Human body is a perfect reflector of gigahertz-range microwaves, so any object attached to it will be seen as having one or several additional reflecting surfaces. Owing to the fact, that metals (conductors) and dielectrics reflect EM waves differently, the detection system can provide the following information about the inspected target:

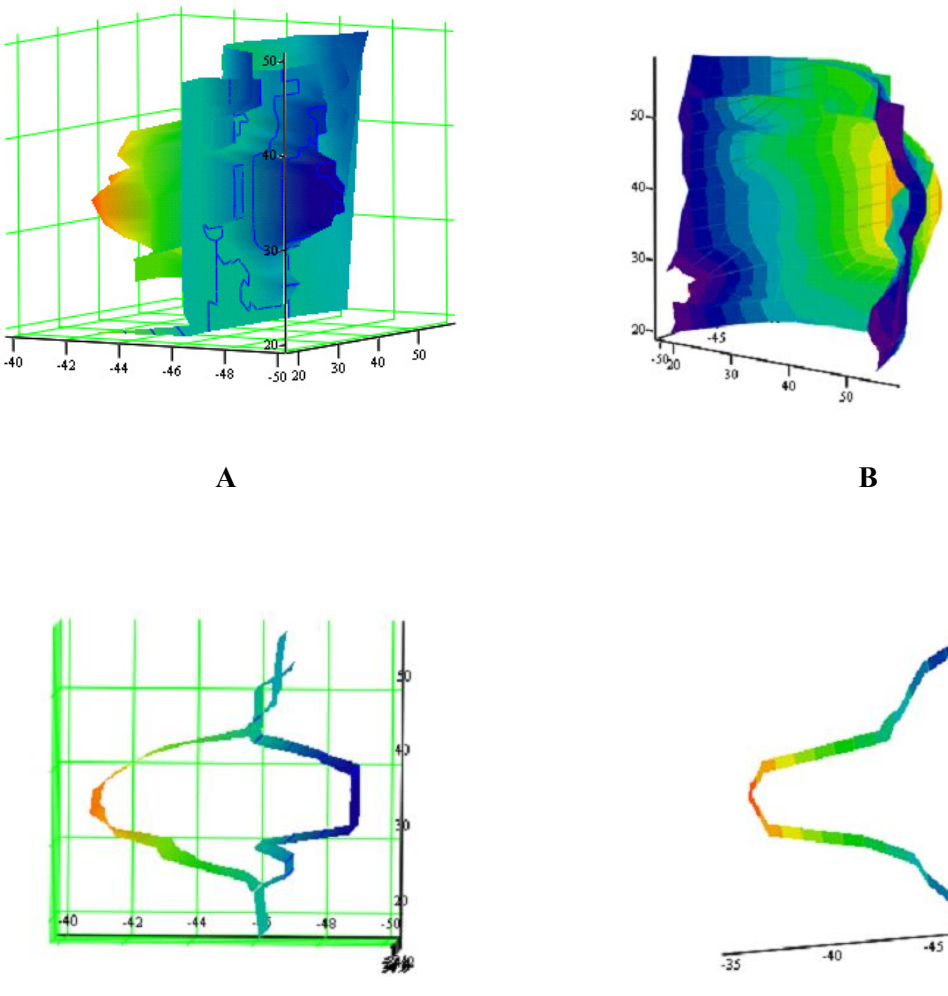
- 3D image of objects hidden on human body.
- Classification of detected objects into metals/dielectrics.
- The value of the dielectric constant of the object (if it is a dielectric).
- The mass of the concealed object in TNT equivalent.

Figure 2. Experimental setup with two antennae. A "suicide bomb" was simulated by wax attached to the body and covered by a raincoat.

Dielectric characteristics of several types of real explosives have been determined in dedicated experiments. Though not a unique characteristic of explosives, dielectric constant is an important additional indicator, which allows one to distinguish between concealed explosives and, say, a wallet containing plastic, paper etc.

The laboratory prototype for detection of explosives concealed on human body is shown on Figure 2. The rectangle on the left photo indicates the boundaries of the inspected region. The laboratory prototype was working in the frequency range 2-8 GHz and emitted coherent microwaves with frequency step dF = 125 MHz. The radiating aperture was synthesized by moving the elementary antenna with uniform step of 2 cm along vertical and horizontal axes within the rectangle with dimensions 60 cm × 40 cm.

The "bomb" was simulated by a block of wax (dielectric properties of wax are rather close to those of standard explosives) attached to the body. In some experiments wax was wrapped in aluminum foil, which was not transparent for electromagnetic waves.



A **B**

C **D**

Figure 3. 3D images of the area containing wax: A – not wrapped in foil; B – wrapped in metallic foil. Panels C and D show cross-section of the corresponding 3D plots.

3D images of the wax attached to human body are shown on Figure 3. Since the wax simulator is a dielectric, its image has two surfaces (A, C): the first surface is the front border clothing-simulator, the second is the border simulator-body, which is located from the front border at distance, determined by the electrical length of the simulator. For the wax wrapped in metallic foil (B, D) only the first border is visible, since the electromagnetic waves cannot penetrate the foil.

Analysis of Figure yields the following conclusions about the found object:

- The object attached to human body is a dielectric.
- Dielectric constant of the object is 2.6 (correct for wax).
- Mass (in TNT equivalent) of the detected object is 1.8 kg.

3.0 EXPECTED CHARACTERISTICS OF MS-SRIP

Expected characteristics of the full-scale system:

- Frequency range: several tens of gigahertz.
- Dimensions of the antenna: 1m×1m.
- Resolution: $2\times2\times1cm^3$ at 2 m; $4\times4\times1cm^3$ at 4 ; $10\times10\times1cm^3$ at 10 m.
- Secrecy: imaging of moving targets; people do not have to stop in front of the device.
- Real-time operation.
- Safety: no “real” focusing of microwaves; emitted power less than that of a mobile phone.
- No privacy issue: resolution is enough for detection of explosives, but not enough for revealing body details.

4.0 FURTHER PLANS AND CONCLUSIONS

Gigahertz-range electromagnetic waves have been shown to be an adequate tool for standoff detection of “suicide bombs” on human body.

Any useful system for standoff detection of “suicide bombs” must be able to examine moving people in real-time. To achieve that goal, an antenna array has been developed (see Figure 4), which does not contain moving parts and can provide images at a rate of up to a 100 frames per second. The high frame rate is achieved by a combination of parallel and sequential data collection and processing.

Further work will include:

- further development of the methodology of remote inspection of human body by microwave technique; experimental investigation of the maximal detection distance keeping emitted power very low; conceptual design of MS-SRIP system;
- development and optimisation of the data collection, data analysis, and visualization software;
- production and testing of a fully functional laboratory prototype;
- production of a full-scale prototype of MS-SRIP; tests and demonstration at test-grounds.

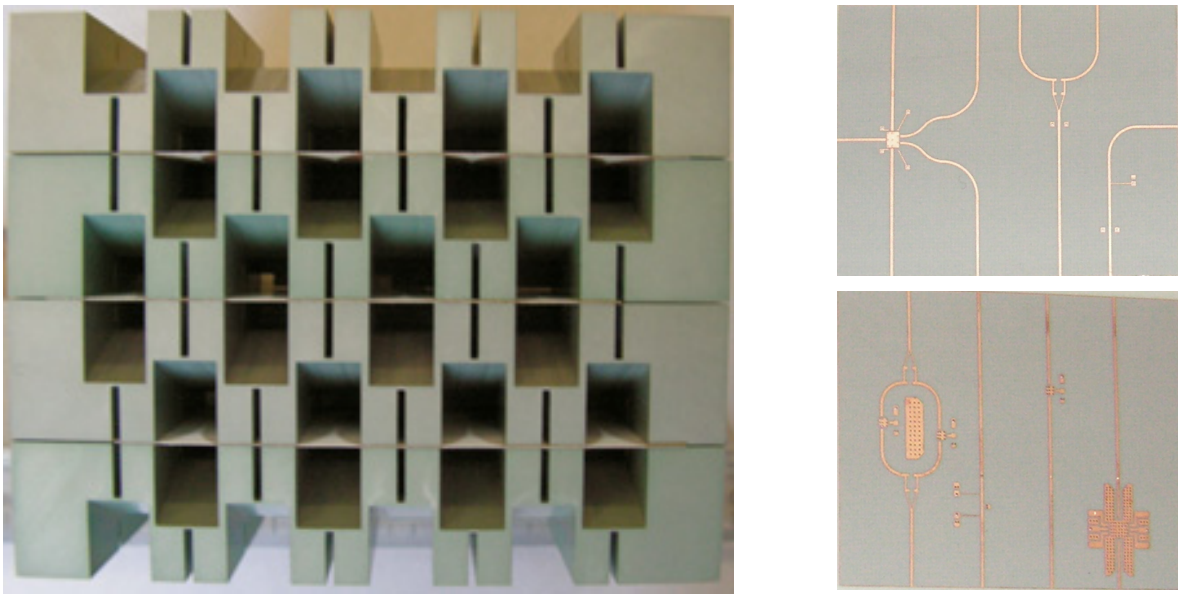


Figure 4. Prototype super-broad-range 2D antenna array and micro strip line UHF components.

5.0 REFERENCES

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