Some Experiments Concerning Resolution of 32 Sensors Passive 8 mm Wave Imaging System

A. Denisov, V.Gorishnyak, S.Kuzmin, V.Miklashevich, V.Obolonskv, V.Radzikhovsky, B.Shevchuk, B.Yshenko, V.Uliz'ko, J.Y.Son

Abstract—**Passive 32-sensors imaging system operating in 8-mm waves band has been tested at SRC "Iceberg" over the last time. This system consists of the focal plane array connected with processor, quasi-optical antenna and scanning mechanism. The system provides the 120 x 16 degrees field-of-view, and displays the acquired image during 3 seconds.**

Sensitivity of the sensor in total power mode is better than 10 mK at integration time τ = 1 sec. It was necessary and interesting to evaluate some technical parameters, concerning the resolution on radio images. Some experiments performed by using the metal lists with sizes 1,25 m x 2,5 m and under the angles 25…70° to azimuth surrounded at the distance 500 m from passive imaging system.

Index Terms – **Passive millimeter wave imaging systems, radiometer, resolution, sensitivity**

I. Introduction and Background

Passive millimeter wave sensors provide the ability to see through fog, clouds, smoke and dust, drizzle, dry snow, smoke, and other obstacles makes the millimeter waves imaging systems the most efficient instrument to resolve a wide scope of problems which can't be solved with help of infrared and optic systems.

At the same time the absence of any active radiation as in radars can be used for the remote and invisible control of the neighborhood situation in case of enough small, middle and real distances. Reasonable to say this time there exists big boom in field of the design and production the various passive microwave systems [1, 2] for the finding the concealed objects under closing. Such devices have some the same technical task. Possibly it is necessary to remark that such systems for security will not find wide application according to short working distances, the presence of the special control chambers or the understanding about remote control.

In our opinion the real microwave remote systems for the security items will find the real wide application in case of the working distances not smaller than 10 meter (or more).

In this case it will be possible to provide some invisible control, don't think beforehand firstly about small size of system and to have enough safe distance. Naturally according to more big distance it will be necessary to use the receiving antenna with bigger diameter according to size of one pixel on the microwave image. At the same time reasonable to remove all unnecessary microwave losses before the sensors with best sensitivity and to use the radiometric scheme of the full power mode.

According to such preliminary analysis and our real current possibilities with 8 mm microwave components it was designed and produced the experimental system for the remote control of the neighborhood situation.

Manuscript received 19 April 2009. This work was supported in part by the joint scientific program between Ukraine and Republic of Korea

A. Denisov, V.Gorishnyak, S.Kuzmin, V.Miklashevich, V.Obolonskv, V.Radzikhovsky, B.Shevchuk, B.Yshenko, V.Uliz'ko are with the State Research Center of Superconductive Radioelectronics "Iceberg", Kiev, Ukraine, tel/fax: +(38-044)-526-54-54, e-mail:denisov@ukrpack.net

J.Y.Son is with the Hanyang and Daegu University, Kyungbuk(in Daegu), 712-714, Republic of Korea, Tel:. +(82-17)-232-57-91, e-mail: sjy5002@gmail.com)

II. Results

The focal plane array is built on base of radiometric sensors [3,4], which are direct detection receivers with input low-noise amplifiers. The sensors operate in frequency band 33…38 GHz and have temperature sensitivity not worse than 10 mK/Hz$^{1/2}$ in total power mode. Small sizes of the sensors (14 x 14 x 80 mm) and stretched configuration provide its efficient packing into array. The array contains 32 sensors located in form of two vertical rows. Each row contains 16 sensors. The rows are shifted relative to each other in such way to form with antenna 32 beams, which will draw 32 strips during first scanning of array with antenna in horizontal direction and 64 strips after second (reverse) scan. The elevation angle of antenna with array changes at the end of the every horizontal scan on 120 °.

Multi-beams quasi-optical antenna consists of the main antenna and feeds located in focal plane of the main antenna. The prime-focus-fed parabolic reflector is used as main antenna. The reflector has diameter D = 900 mm providing the beam width near 0.6 degrees at 3 dB level. The focal length of antenna F = 990 mm, that satisfies to condition F/D ≥ 1 for multi-beams antennas.

As feeds the dielectric (ε = 2.1) rods antennas are used. This type of feed has smaller cross size compare with horn feeds that allow more compact to arrange the sensors in the array construction. Real construction has the sizes on Fig. 1.

Antenna with array is attached to the scanning mechanism; hitch provides the scanning of an antenna in the horizontal plane by angle ± 60°. At the end-points of each scan the calibration of the sensors is carried out. The calibration noise sources represent the quasi-optical wide aperture reference radiators which provide the calibration signals for the all

Fig.1 Passive 8 mm imaging system and her real sizes

receiving channels. The radio-absorbing material was used for the coating of the radiators. The standing-wave ratio of the quasi-optical reference source ("loading") does not exceed 1.15. Metallic plates inside of radiators is cooled till T_1 = 278 K (5 C) by means of the thermal-electric coolers or heated at T_2 = 323 K (50 C) with an accuracy ± 0,1 K with help of the electronic unit of the temperature stabilization. The calibration reference sources were mounted on the fixed section of the system in such way that at the beginning of the each antenna scan "cold" and "hot" reference overlaps all feeds in the calibration parts of the scanning sector.

During the scan, each beam draws the horizontal strip, and thus all observed scene find itself completely covered by beams. The scanning mechanism includes the optical sensor of the angle, which gives information about the antenna position in any time during the system operation. The reading of the signals is carried out through each 0.17 degree (1 pixel) in full angle of view in the horizontal plane 120 ^{o}.

The scanning mechanism is designed on the base of the usual asynchronous three-phase motor. The axis of the motor is mounted vertical. The antenna with array is mounted on the motor's axis.

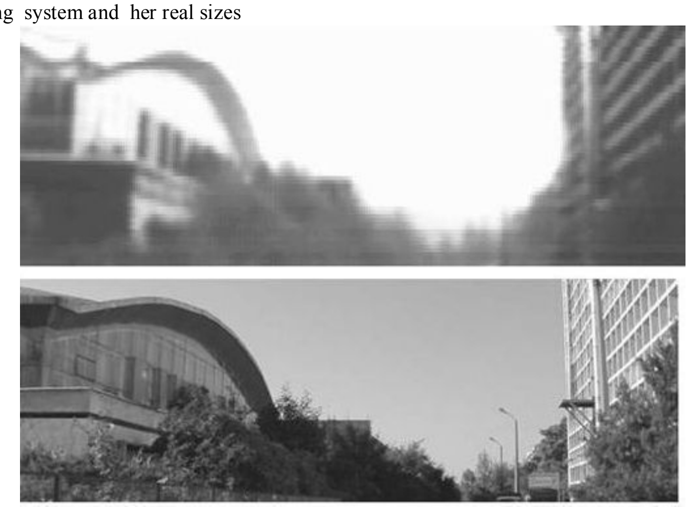
Fig.2 Buildings near the SRC "Iceberg" - 8 mm image and optical

Power applies to a motor from converter, which transforms a single-phase voltage (220 V) into three-phase pulse-duration voltage. The converter is controlled from the computer and provides switch-on and switch-off operations of the motor, the smooth stop and reverse. In order to facilitate a

PRINCIPAL "ICEBERG" MEASURING
produced by *32 sensors Passive Imaging 8 mm System* outside of Kiev -73 km village Vasiliv – 3 November 2007

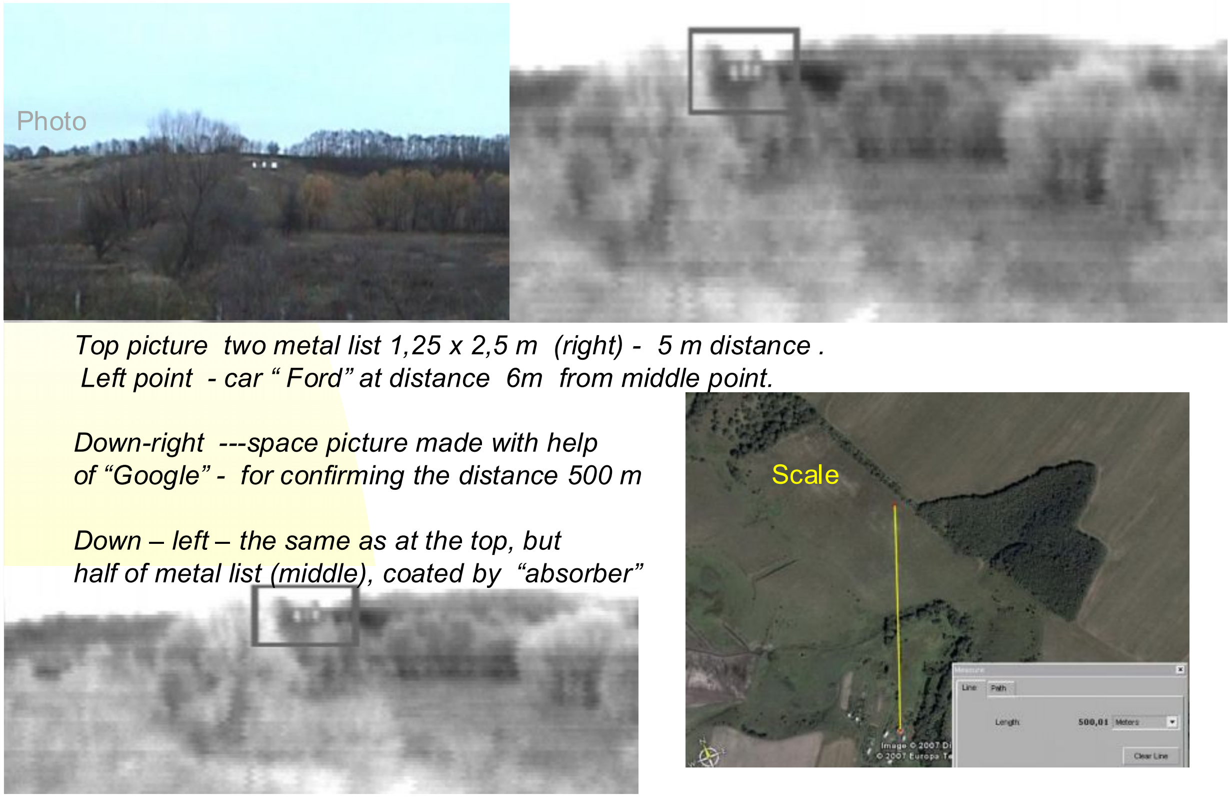

Fig.3 Some results concerning resolution on 8 mm image.

Fig.4 From the top of building. Optical and the same 8 mm images

load onto the motor at time of reverse the special springs are used. On practice the current is not going to the motor during the time of reverse.

Real 8 mm images cut off to the same size of optical image presented on fig.2…4. According to high sensitivity of sensors it was possible to register the some active radiation from some places of city (darkest places on Fig.4) where the retransmitted stations for mobile phone are surrounded – possibly it is the harmonics of main frequency. This technical possibility can be really used for the ecological and electromagnetic radiation dirty control.

It was interesting to evaluate some technical parameters, concerning the resolution on radio image which were evaluated with the help of metal lists with sizes 1,25 m X 2,5 m and the angles 25…70 ^{o} to azimuth surrounded at the distance 500 m from passive imaging system. This results presented on Fig.3. Reasonable to remark the theoretical evaluation the possibility to see the small size metal object under our technical conditions are poor than experimental one.

III. CONCLUSION

Passive 32-sensors imaging system operating in 8-mm waves band has been tested and provided the 120 ^{o} x 16 ^{o} field-of-view, and displays the acquired image during 3 seconds. This time there exists the technical decisions for the design the imaging system which can provide 360 ^{o} image at the same time in 8 and 3 mm wave bands.

REFERENCES

[1] J.M.Chamberlain "Developments in PMMW and THz imaging", Proc. of SPIE, vol.5619, pp.1-15, 2004

[2] http://www.brijot.com, http://www.sago.com, http://www.millivision.com, http:// www.thruvision.com, http://www.xytrans.com

[3] V.N.Radzikhovsky, V.P.Gorishniak, S.E.Kuzmin, B.M.Shevchuk, "16-channels millimeter-waves radiometric imaging system", MSMW'2001 . Symposium Proceedings. Kharkov, Ukraine, June 4-9, pp.

[4] V. Gorishnyak, A.Denisov, S.Kuzmin, V. Radzikhovsky, B.Shevchuk "8 mm Passive Ima ging System with 32 channels" , EurRAD , Amsterdam, Netherland, 2-14 October, 2004