Active and Passive mm-Wave imaging for Concealed Weapon Detection and Surveillance

S. Stanko, D. Nötel, A. Wahlen, J. Huck, F. Klöppel, R. Sommer, M. Hägelen, H. Essen
Research Institute for High-Frequency Physics and Radar Techniques, FGAN-FHR

D-53343 Wachtberg-Werthhoven, Germany

Abstract—**Sensors used for security purposes have to cover the non invasive control of men as well as surroundings of buildings. The work described in this paper concentrates mainly on sensors at 0.1 and 0.2 THz, which are able to detect non metallic objects like ceramic knifes as well as metallic objects hidden under clothes. Here we show active and passive systems, based on state-of-the-art solid-state components.**

I. Introduction And Background

SECURITY checks are getting more and more common in several areas of life. These can be a nuisance for passengers or visitors undergoing the security checks, as today's approaches tend to take more and more time compared to the flight or venue itself. On the other hand, the security personnel faces increasing numbers of people to be screened. Taking into account that each technical aid, like metal detectors and X-ray machines, can only deliver a limited set of information, each new system can add an indication which may help to distinguish actual threat material from other items. This, in turn, can help to increase overall security while reducing the annoyance that a security check can be today. As in former times, passengers at airports spend most of their time waiting for their luggage or mounting the airplane, now more and more time has to be spend on the security checks. Also, the threat has changed, because terrorists prepare to mislead classical metal detectors. This is why new systems are necessary, which are capable to detect concealed weapons and explosives, even if they are not made of metal.

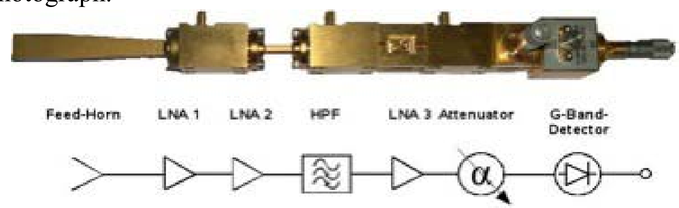
Furthermore, mm-wave imaging, as well as active radar techniques, can be used to operate in a standoff scenario. This means that persons can be screened at distances of up to 20 meters. This field of application will be very important in the future, to detect a potential danger already before the hazardous person can enter a sensitive area or building.

II. Experimental Setup

We describe and compare two different approaches for Concealed Weapon Detection using mm-wave technique.

One possible approach to detect concealed weapons is by using radiometric systems. In principle, a scanner using this technique measures the thermal noise of the radiation reflected by the body. This is equivalent of the temperature on the surface of the body. At mm-wave frequencies the radiation is capable of penetrating clothes and other materials, with transmissions of t = 0.3…0.8. To find the optimal frequency range a compromise is used where an optimum has to be found between transparency of the clothes worn by suspicious people and the reflectivity of dangerous materials.

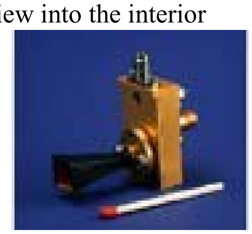
The experimental setup is shown in the following photograph.

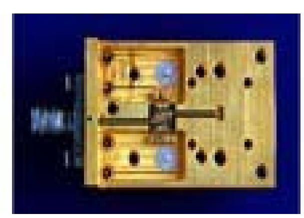


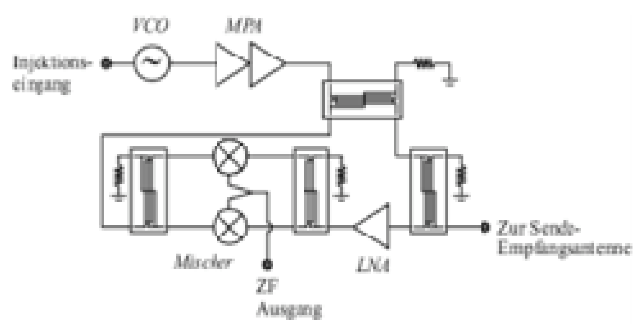
This photograph shows the receiver, when using a chopper wheel for calibration. Alternatively, a switch is mounted between the horn and the first LNA stage. The total gain of the receiver is more than 50 dB, giving a noise temperature of about 2000 K.

Another approach for concealed weapon detection is the use of active radar sensors. We use two different systems here, a single chip FM-CW radar used at a security check door, as well as the experimental coherent broadband radar KOBRA, which is working at distances of 135m standoff.

The radar modules used for the demonstrator were operated in a FM-CW mode, thus guaranteeing the highest possible average power. The radar modules used for the demonstrator were developed at Fraunhofer IAF, Freiburg. The following photo shows the assembled module with horn antenna and the view into the interior







The modules were fabricated using advanced 0.1 µm HEMT technology. In the above figure the block diagram of the monolithically integrated 94-GHz radar module is shown. The output power at the nominal frequency of operation was

978-1-4244-2120-6/08/$25.00 ©IEEE.

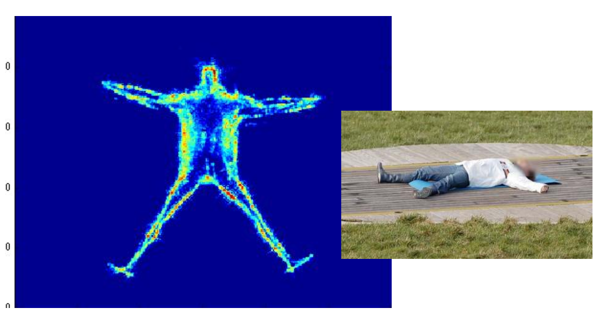
about 2 mW. The low noise amplifier in the input stage of the receiver with a noise figure of about 3 dB allowed for an excellent sensitivity of the radar.

III. Results

The next figure shows a standoff scene which was performed for test purpose. To increase the contrast in this measurement, the person and the bicycle were put in front of an absorber material, so the reflection of the diffuse illumination gives a very good image quality. By deconvolving the data with the measured beam, a better image quality can be achieved. The measured beam size is 0.23° FWHM, which is close to the theoretical value of 0.18° using the above configuration at 220GHz.

The following surveillance image is taken with a passive radiometric system working at 220 GHz. All given objects can be clearly identified.

The other image shown is an active ISAR image taken at a distance of 135m using the KOBRA-220GHz radar system. Here, the hidden objects can clearly be seen.



IV. Conclusion

Two approaches for concealed weapon detection were shown, one using a radiometer, the other employing FM-CW radar systems and SAR / ISAR techniques. The passive system delivers encouraging results with a good image quality and the possibility for standoff detection, at rather long scanning times. The active sensors offer higher scanning speed and work independent of in- and outdoor conditions. However, due to the monostatic geometry it is much more difficult to detect and image concealed metallic or non-metallic objects with an active scanning system. In this configuration an overlaid optical image has to help for concealed weapon detection.

References

[1] A. Tessmann, A. Leuther, M. Kuri, H. Massler, M. Riessle, M. Zink, H. Essen, S. Stanko, R. Stibal, W. Reinert, M. Schlechtweg, "220 GHz Low-Noise Amplifier Modules for Radiometric Imaging Applications", EuMIC 2006.

[2] A. Tessmann, S. Kudszus, T. Feltgen, M. Riessle, C. Sklarczyk, and W. Haydl, "Compact single-chip w-band fmcw radar modules for commercial high-resolution sensor applications," IEEE Transactions on Microwave Theory and Techniques 50, p. 2995, 2002.

[3] H. Essen, A. Wahlen, R. Sommer, W. Johannes, R. Brauns, M. Schlechtweg, A. Tessmann, "High-bandwidth 220GHz experimental radar", Electronics Letters, Vol. 43, Issue 20, p. 1114-1116, 2007

978-1-4244-2120-6/08/$25.00 ©IEEE.