

Emission Measurement of a Full Body mm Wave Scanner

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Abstract—The emission of a full body scanner Rohde & Schwarz QPS 100TM has been measured traceable to the SI units in the operation frequency range of the device between 70 GHz and 80 GHz. The measurements which have been performed with a calibrated spectrum analyzer and calibrated horn antennas are discussed with regard to the safety limits for non-ionizing electromagnetic radiation.

I. INTRODUCTION

THE question whether non-ionizing electromagnetic radiation with power densities below the safety limit of 1 mW/cm^2 as set by the International Commission on non-ionizing radiation protection (ICNIRP) for the frequency range between 2 GHz and 300 GHz [1] can cause detrimental health effects is still under debate. In any case authorities responsible for the admission of full body scanners, customers and researchers examining bio-electromagnetic interaction need a reliable quantification of the scanner emission.

Here we measured the radiation emitted by a Rohde & Schwarz QPS 100TM in its regular operation mode as well as in a special single frequency operation mode. The scanner shown in Fig. 1 consists of two antenna arrays containing 16 antenna clusters, each. The 32 clusters contain two rows of 47 transmission antennas, each. Altogether, the scanner contains 3008 transmission antennas with diagonal polarization that are switched on consecutively [2]. The scanner operates at 64 distinct frequency points equally spaced in the operation frequency range between 70 GHz and 80 GHz. A scan is performed by transmitting with each transmitter antenna for 287 ns at a distinct frequency. Then the next antenna is switched on and the first is switched off. Only one antenna is switched on at a time. After switching on all antennas, the procedure is repeated with the next frequency. In the normal operation mode this procedure is repeated continuously. The spectral content of the 287 ns pulses has been found to span up to 20 MHz. In addition to the normal operation mode, a single frequency scan mode for testing purposes can be chosen, where the antenna switching is restricted to a distinct frequency, only.

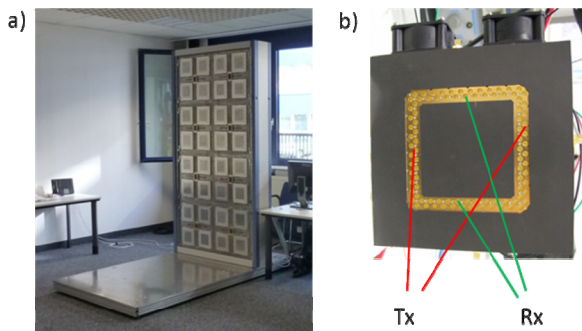


Fig. 1. a) Photograph of scanner panel and b) photograph of a single cluster with transmitter antennas (Tx) arranged horizontally and receiver antennas (Rx) arranged vertically.

II. MEASUREMENT SETUP

The emission as seen by a scanned person or operation personnel in the operation frequency range of the device between 70 GHz and 80 GHz has been measured traceable to the SI units with known measurement uncertainty [3] using calibrated equipment as shown in Fig. 2. The measurements have been performed with a calibrated spectrum analyzer (Rohde & Schwarz FSU 67 with V band mixer FS-Z75 and W band mixer FS-Z110) and calibrated horn antennas (Flann 25240-20 for the V band and Flann 27240-20 for the W band). Two approaches have been taken:

1) Measurement of maximum power densities at several distinct locations in front of the scanner using the MaxHold modus of the spectrum analyzer and the Peak detector to get sufficient measurement dynamics for mapping the field.

2) Measurement of averaged power densities as required by the ICNIRP guidelines using the RMS detector, the 0-Hz-Span modus, sweep times of 44 s (ICNIRP requirement for 75 GHz) and Time-Domain Power averaging at few distinct locations with less measurement dynamics.

From the measured power level and the antenna gain, the power density was determined using the effective antenna area.

III. RESULTS

Fig. 3 shows the results of maximum power density measurements (approach 1) for different distances between scanner panel and horn antenna and for heights specified in Fig. 2 b). The measurements have been performed close to the panel (5 cm), at a typical scanning distance (50 cm) and for a distance where operators or other persons could be located (100 cm). The maximum power densities measured at a distance of 5 cm to the scanner panel did not exceed 0.063 mW/cm^2 (6.3% of safety limit). In a distance of 50 cm they did not exceed 0.00083 mW/cm^2 (0.083% of safety limit). In a distance of 100 cm they did not exceed 0.00028 mW/cm^2 (0.028% of safety limit).

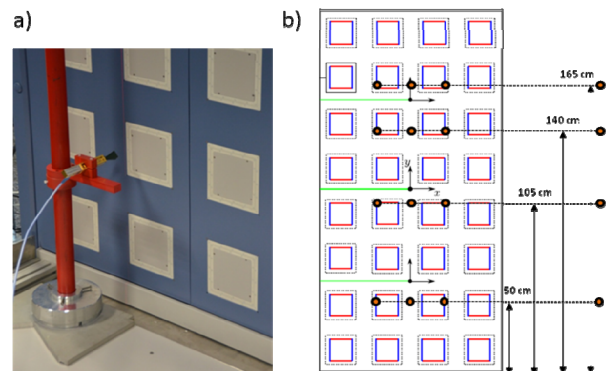


Fig. 2. a) Photograph of mixer and antenna fixture and b) measurement positions.

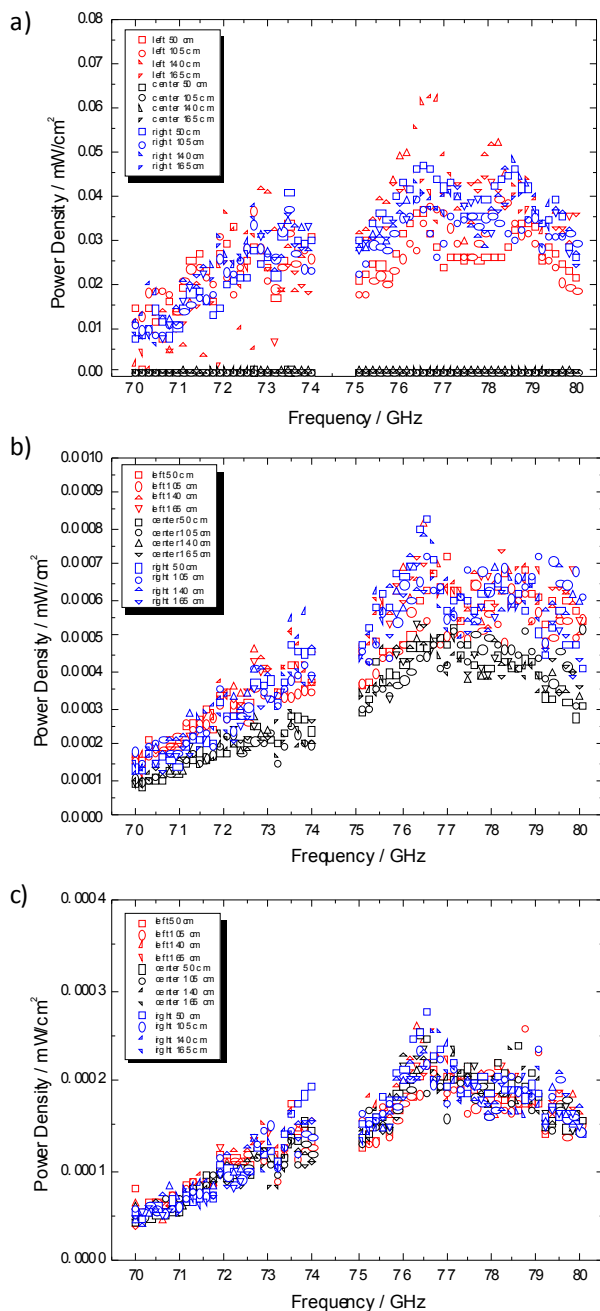


Fig. 3. Results for a) 5 cm, b) 50 cm and c) 100 cm measurement distance to the panel.

Measurements of averaged power densities (approach 2) have been taken for a fixed scanner frequency of 75.396 GHz for different distances to the scanner panel between 5.5 cm and 65.5 cm (Fig. 4 a) and for two distinct distances of 5.5 cm and 55.5 cm with different settings of the fixed scanner operation frequency (Fig. 4 b)).

For both measurement approaches we estimate an expanded measurement uncertainty (95% confidence interval) of 32%. In addition to contributions from the measurement equipment (mainly the mixer and the antenna calibration) the main source of uncertainty are standing waves between measurement antenna and scanner panel, which cannot be avoided completely.

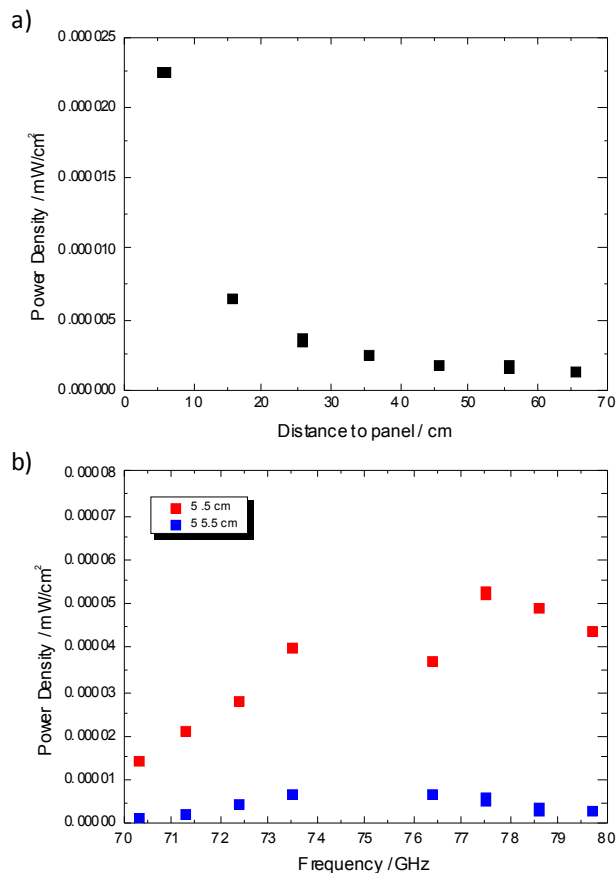


Fig. 4. Averaged power density according to ICNIRP a) as a function of distance to the panel in front of a distinct antenna and b) as a function of the selected test frequency for two different measurement distances.

IV. SUMMARY

We described a procedure to measure the emission from a security scanner in its frequency range of operation between 70 GHz and 80 GHz based on calibrated measurement instruments and therefore traceable to the SI units. We found radiated power densities far below the safety limit of 1 mW/cm².

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REFERENCES

- [1]. ICNIRP Guidelines for limiting exposure to time varying electric, magnetic, and electromagnetic fields (up to 300 GHz), Health Phys., vol. 74, pp. 494–522, 1998.
- [2]. S. Ahmed, Fully Electronic Active E-band Personnel Imager with 2 m² Aperture, Int.l Microwave Symposium IMS, Montreal, Canada, 2012.
- [3]. ISO/IEC Guide 98-3:2008: Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurement. ISO, Genf 2008.