

Exposure assessment of 60 GHz communication antenna and 79 GHz automotive radar

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SHORT ABSTRACT

We measured the exposure, in terms of spatial-averaged power density, of a 60 GHz wireless communication module and 79 GHz automotive radar at distances less than 30 mm of the antenna. We assessed the upper limit on the exposure by transmitting maximum power and at 100 % duty-cycle and compared this upper limit to the ICNIRP and FCC basic restrictions. The upper limit complied with ICNIRP basic restrictions, but exceeded FCC basic restrictions at short distances of the antennas. This difference in compliance is mainly due to the difference in averaging area and limits specified by both guidelines.

INTRODUCTION

Two emerging applications of millimeter-wave electromagnetic fields are (automotive) radar and (short-range) wireless communications. The increasing demand for high – Gbit – data rates and mobility drives advances in wireless communications. The next step in the evolution of wireless communication technologies is 5G. To cope with the demand for high data rates, millimeter-wave communication bands will be introduced with 5G communication technologies; targeted millimeter-wave frequencies are 28 GHz and 60 GHz. Automotive radar is another application that utilizes millimeter-wave frequencies. Advances in these radar applications are driven by the development of self-driving vehicles, such as, cars, which rely strongly on various sensing technologies, amongst them automotive radars. In both cases, antennas can be positioned in close proximity – within a few centimeters – of the human body. An important aspect in the development of these devices is the assessment of the localized exposure.

The objective of this study was to assess experimentally an upper limit – for maximum output power and a 100% duty cycle – on the exposure of a 60 GHz communication module and a 79 GHz automotive radar module and evaluate the measured exposure, in terms of spatial-averaged incident power density, against current ICNIPR and FCC guidelines.

MATERIALS AND METHODS

We measured the near fields in the proximity of a radiating 60 GHz communication module (60 GHz 16-elements phased array beam steering antenna for high data rate WiFi and 5G small cell backhaul [3]) and a 79 GHz automotive radar antenna [4]. To assess an upper limit on the exposure, we applied maximum power and a 100% duty-cycle for both antennas. Figure 1 shows the measurement setup consisting of a EUMmWV2 near-field probe (SPEAG, Zürich, Switzerland) connected to a DASY6 (SPEAG, Zürich, Switzerland) and a module under test. The EUMmWV2 is designed for near field measurements in the millimeter-wave range up to

a frequency of 110 GHz with a dynamic range of $<50 - 3000$ V/m, and a linearity error of less than ± 0.2 dB. We positioned the antennas horizontally resulting in an upwards radiation and measured the exposure in horizontal planes at distances of 3 mm, 5 mm, 20 mm, and 30 mm above the antenna surface. We compared the measured spatial-averaged power density, in W/m², with ICNIRP [1] and FCC guidelines [2]. ICNIRP specifies two limits: 10 W/m² averaged over 20 cm² and 200 W/m² averaged over 1 cm²; FCC specifies a limit of 10 W/m² averaged over 1cm² at these frequencies.

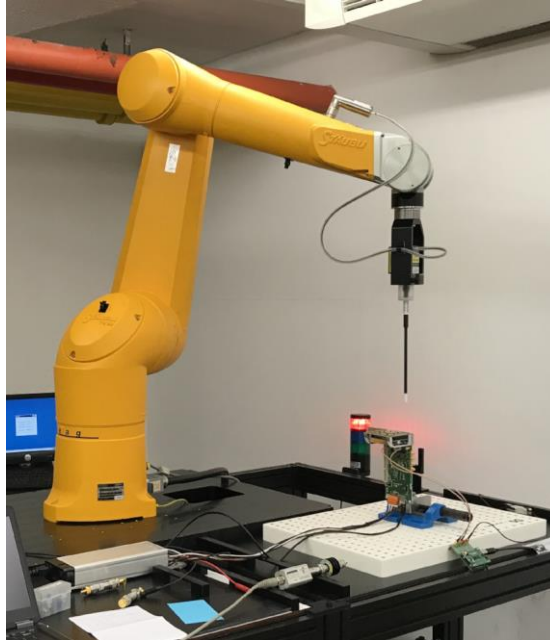


Figure 1: The measurement setup consisting of the precision millimeter-wave near field probe connected to a DASY6 measurement system (SPEAG, Zürich, Switzerland) and the millimeter-wave communication device.

RESULTS

Figure 2 shows the distribution of the power density (S) of the 60 GHz communication antenna and the 79 GHz automotive radar antenna; Figure 3 shows the spatial-averaged power density (S_{avg}) over 1 cm² and 20 cm² with the height above the antenna for both millimeter-wave antennas. As we opted to determine an upper limit on the exposure by both devices, the devices were transmitting at maximum power with a duty-cycle of 100 %. These configuration settings will allow us to easily rescale exposure values and evaluate compliance in case of realistic exposure scenarios.

We observed that the upper limit on the exposure complied current ICNIRP basic restrictions at all the measured distances from the antenna surface, but it did not comply with FCC basic restrictions at short distances of the antenna surface. We extrapolated the compliance distance: the radar antenna complied FCC basic restrictions for distances larger than 23 mm; the communication antenna complied FCC basic restrictions for distances larger than 50 mm. As the antenna configurations were set to provide an upper limit the exposure, the presented exposure values will overestimate realistic exposure conditions. The different compliance outcome when compared with ICNIRP and FCC basic restrictions are due to the difference in the specified averaging area and limits by these guidelines.

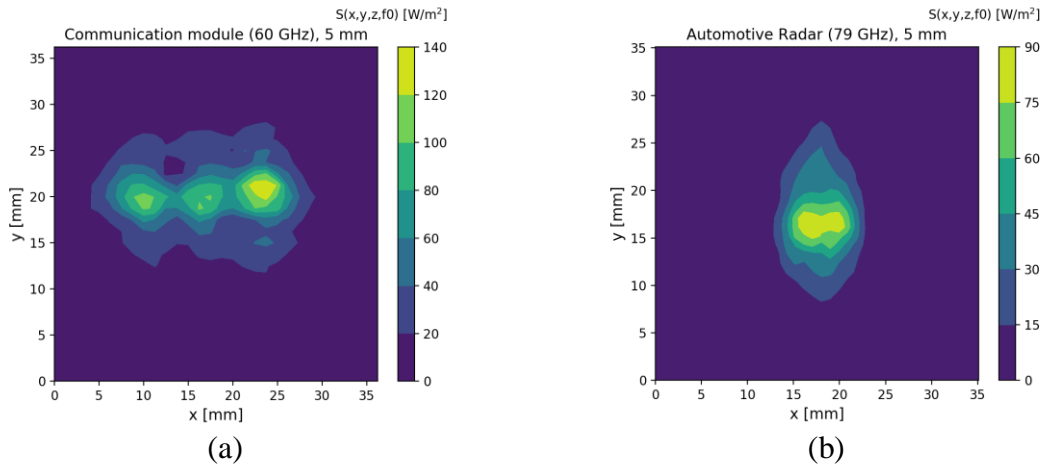


Figure 1: Power density distribution measured in a horizontal plane at 5 mm above the surface of (a) the communication module antenna at 60 GHz and (b) the automotive radar antenna at 79 GHz.

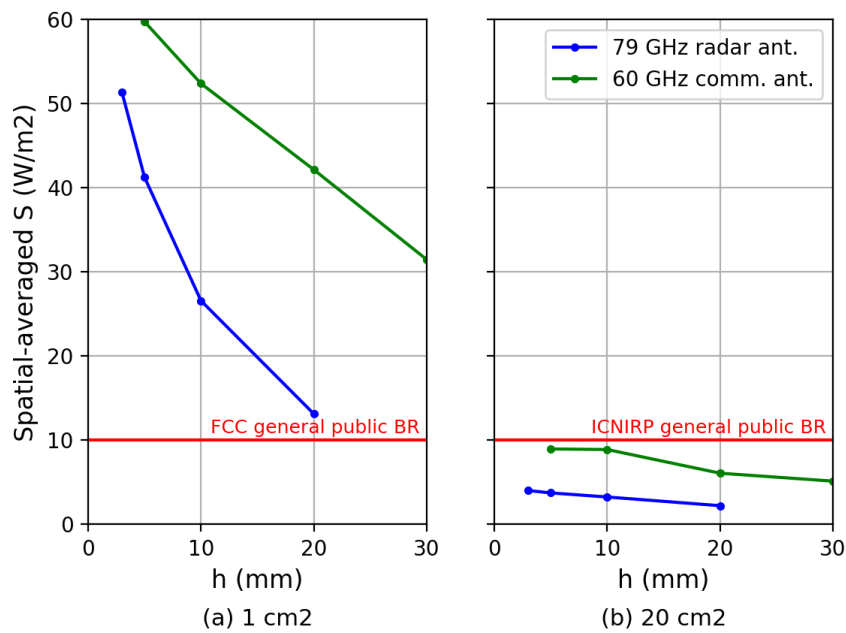


Figure 2: Comparison of the measured spatial-averaged power density from the 60 GHz communication antenna and 79 GHz radar antenna with current ICNIRP and FCC basic restrictions. The shown spatial-averaged power densities provide an upper limit on the exposure as maximum power and 100% duty cycle was used. Hence, the presented exposure values overestimate realistic exposure conditions.

CONCLUSIONS

We measured experimentally the exposure of a 60 GHz millimeter-wave communication module and a 79 GHz automotive radar antenna. We assessed the exposure for maximum power and 100 % duty cycle. A large difference in compliance distance between FCC and ICNIRP guidelines is observed for millimeter-wave electromagnetic field exposure. This is due to the difference in averaging area and limits specified by both guidelines.

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