Power Density in Proximity to a 4000/4100 Transceiver using any Terma SD, HG or LA Antenna

SCANTER 4000/4100
Record of Changes

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1 INTRODUCTION

Terma has in recent years been successful in the development of novel receiver and processing technology, reducing the required transmitter power for a given radar performance. This does substantially reduce the microwave radiation when compared to that possible just a few years ago. However, there is an increasing concern in the public about radiation from microwave sources. This document was therefore made to summarize the results from an analysis of the incident microwave power levels (safety levels) present in the vicinity of SCANTER 4000/4100 radar systems.

All restricted data has been omitted and the document may therefore be released to third parties on a need to know basis (as decided by end users of the radar systems).

Two different safety levels, one for the general public and one for occupational exposure, are defined in guidelines from the International Commission of Non-Ionizing Radiation Protection, ICNIRP [1]. The ICNIRP guidelines have been used throughout the analysis.

The main conclusions in relation to SCANTER 4000/4100 radars using any of the Terma standard (SD), high gain (HG) or large aperture (LA) antennas are:

- The ICNIRP recommendations for general public and occupational staff are met for all locations beyond 12m in the horizontal plane from or 1m above/below the antenna.
- Microwave power is not emitted from any parts of the SCANTER 4000/4100 system, but from the antenna.

The antenna will typically be elevated at least 30 meters above ground levels when the SCANTER 4000/4100 radar is used for land based applications. In such case, the microwave power exposure at ground level was calculated to be a factor of 100 or more below the ICNIRP recommendations for general public.

An artistic impression of the safety limits is shown on the next page.

2 REFERENCED DOCUMENTATION

Artistic impression of calculated safety region applying for any Terma standard, high gain or large aperture antenna. 30 meter high tower
3 THE SCANTER 4000/4100 CONCEPT

SCANTER 4000/4100 is a coherent radar system providing Surface and Air Surveillance. Depending on the application, the system comprises one transmitter/receiver and one or two antennas.

The transmitters, transmitting on separate frequencies within the 8.8GHz to 9.45GHz band are utilized. The transmitted power may be directed to one antenna or may be distributed between two antennas using a programmable power split ratio. The concept giving the highest transmitted power, was assumed for the analysis referred by this document.

Energy transmitted can be varied depending on operational needs. The highest possible energy has been assumed for the analysis. For the average power analysis 1000W is applied. For the peak power analysis, 20kW is applied.

The analysis is based on antennas of the standard (SD), high gain (HG) and large aperture (LA) types. All antennas have been analyzed at the 9.305GHz frequency, except for the 15’ LA-HP/CP-C-39 antenna that has been analyzed at 8.893GHz. The results for the 15’ LA-HP/CP-C-39 antenna are nevertheless representative for an antenna within the 9.14GHz to 9.50GHz with a similar antenna pattern.

For each of the three antenna types the following antenna variants exist:

Standard antennas:
7’ SD-HP-F-31, 12’ SD-HP-33 and 18’ SD-HP-F-35.

High gain antennas:

Large aperture antennas:
15’ LA-HP/CP-C-39 and 21’ LA-HP/CP-F-42.

The generation of microwave energy and its transmission to the antenna is confined within an unbroken metal enclosure. Therefore, microwave power is not emitted from any parts of the SCANTER 4000/4100 radar system, but from the antennas.

Transmitters are closed down when the antenna rotation is stopped.

4 POWER DENSITIES

Measurement of radiation levels from radar systems is a specialized task and radiation levels are therefore often determined by assuming the radar to maintain its far-field antenna gain at all distances for energy and determining distant power levels by a simple equation. However, with the large aperture antennas used in the SCANTER radar systems, results from this method may be misleading.

The difference between the simple radar equation and the formulation used by Terma is a number of extensions that allow for modeling of the exact location, the orientation and the type of the transmitting antenna(s). In particular, the formulation allows for careful modeling of the near-field characteristics of a radiating antenna. These near-field characteristics are important as the spreading of the microwave power in the vicinity of the antenna is quite different from the characteristics at large distances from the antenna (in the far-field). Failure
to include the near-field characteristics may lead to over-estimated power densities within the antenna main beam and to underestimated incident power densities outside the antenna main beam.

In addition, the surroundings, which may cause so-called multi-path propagation, must be considered. Reference levels stated by the ICNIRP guidelines include these necessary safety factors to allow for such effects.

The amount of incident power in any position in the surroundings of the microwave source is measured in Watts per m².

According to the ICNIRP guideline, the limit for the incident power density level for the general public is 10W/m² in the frequency band from 2-300GHz and over any 6 minute period. The SCANTER 4000/4100 radars operate within this frequency range.

The corresponding level for occupational exposure is 50 W/m².

Furthermore, the ICNIRP guidelines states that the peak power density shall not exceed the average power density by a factor of more than 1000.

5 RESULTS

5.1 Power density contours

The analysis of incident power density is based on a formulation similar to the radar equation. Each antenna is described in terms of its aperture distribution, which allow for computation of its near-field characteristics.

Average as well as peak power results are presented. The worst of the two are been used for determining the safety distance required to comply with the ICNIRP recommendations.

Allowance for production tolerances has been made.

In Figure 1 through Figure 3 the results corresponding to the peak power limit, i.e. the 10kW/m² limit as recommended by ICNIRP for the general public, are shown for each of the three groups, i.e. standard (SD), high gain (HG) and large aperture (LA) antennas. As the antenna rotation during the short time allowed for the radar pulse is extremely limited, the antenna is assumed non-rotating.

In Figure 4 through Figure 6 the results corresponding to the average power limit for rotating antennas, i.e. the 10W/m² limit as recommended by ICNIRP for the general public, are shown for each of the three groups, i.e. standard (SD), high gain (HG) and large aperture (LA) antennas.
5.1.1 Peak power limitations

Figure 1 Safety distances for standard antennas, 20kW peak power
Figure 2 Safety distances for high gain antennas, 20kW peak power
5.1.2 Average power limitations

![Graph showing safety distances for high gain antennas, 20kW peak power.](image)

Figure 3 Safety distances for high gain antennas, 20kW peak power
Figure 4 Safety distances for standard antennas, 1000W average power
Figure 5 Safety distances for high gain antennas, 1000W average power
Figure 6 Safety distances for large aperture antennas, 1000W average power
5.2 Additional remarks

Additional safety margins in respect to microwave radiation can be obtained by increasing distances to the radiating antennas.

As a rule of thumb, the power density is inversely proportional to the square of the distance from the radiating source. Thus, increasing the distance with a factor of 10 will reduce the power density with a factor of 100.

However, this is only true in the far fields distance. Complex calculations for the region near the antennas show that:

- Power density is a factor of at least 10 times below the ICNIRP recommendations for general public for all locations 5 meter or further below the antenna and at any position beyond 65 meter horizontal distance.
- Power density is a factor of at least 100 times below the ICNIRP recommendations for general public for all locations 30 meters or further below the antenna.

Furthermore, sector transmission is normally implemented, stopping transmission for the parts of the antenna rotation not covering the sea surface.

For additional safety, SCANTER 4000/4100 transmitters are closed down when antenna rotation is stopped. However, transmission into a stopped antenna can be tolerated without violating the ICNIRP recommendations for general public, for all locations 15 meter or further below the antenna or at any position beyond 250 meters horizontal distance.

Finally, for occupational staff, be aware of safety regulations for rotating machinery.