Remarks on methods of measurements

1. General

The device under test is positioned on a non-conductive fixture and can be rotated and tilted relative to the measurement antenna.
The measurements of radiated emissions in the frequency range from 30 MHz to 1 GHz are performed in vertical and horizontal plane in a semi-anechoic chamber, compliant to CISPR 16-1 for test distances of 3m and 10m. The EUT is positioned on a non-conductive support at a height of 0.80 m above the conductive ground plane covering the whole chamber. The measuring antennas can be moved over a height range from 1.0 m to 4.0 m in order to detect the maximum field strength emitted from the EUT. These antennas are compliant with specifications ANSI C63.2-1996 clause 15 and ANSI C63.4-2003 clause 4.1.5.

Radiated emissions measurements in the frequency ranges from 9 kHz to 30 MHz and 1 GHz to 18 GHz are carried out in a fully-anechoic chamber, compliant to CISPR 16-1, providing test distances up to 5 m. EUT and receiving antennas are positioned 1.5 m above the tips of the absorbers.
Measurements between 18 GHz and 240 GHz are performed in certain test laboratory environments, where analyzers up to 50 GHz, without using mixers, and harmonic mixer modules and standard gain horns are available up to 320 GHz.

The measurement distances between EUT and receiving antennas are indicated in the test set–ups for the various frequency ranges. For each measurement, the EUT is three-dimensional rotated until the maximum field strength is received for both polarisations of the measuring antennas.

The wanted and unwanted emissions are received by spectrum analysers where the detector modes and resolution bandwidths (RBW) over various frequency ranges are set according to requirement ANSI C63-4-2003 clause 4.2.

Test equipment and ancillaries used for tests
Calibrations occur according to the EN/ISO/IEC 17025 standard. Calibrations are performed by an accredited external calibration laboratory. Additional to these calibrations, the laboratory performs comparison measurements with other calibrated systems and regular chamber inspections. All used devices are connected to a 10 MHz external reference.

2. Measurements of the EIRP and power density (PD) at fundamental frequency

The measurements are conducted according to FCC rules and, if appropriate to the guideline "Millimeter Wave Test Procedure" with a spectrum analyser (SA), harmonic mixer covering appropriate frequency range and a rectangular standard gain horn antenna (SGH) with matching wave guide dimensions. The conversion loss of the external mixer is taken into account in the SA power level reading automatically.

The radiated power measurements are performed with resolution bandwidth filter (RBW) of 1.0 MHz and a video filter of 1 MHz. Tests are repeated with different RBW, eg. 2.0 MHz and Video bandwidth filter (VBW) 3.0 MHz in order to evaluate whether a calculated bandwidth correction may be performed.

The evaluation distance for fundamental power measurement is 3.0 m. If the far field condition is met, a test distance of 2 m is usually used and compliance with the 3 m requirement is proved by corresponding calculation. The SA level scale is set to the dimension dBm. With the appropriate antenna aperture area the power density can be calculated from the equation:

Power Density	=	EIRP	/	Antenna aperture area [mW/cm ^{2}]
pd	=	eirp	–	a [dB(mW/cm ^{2})]

Field strength measurements in 3m distance are performed in the case of too large far field distances ($R=2*L^2/\lambda$, R = far field distance in meters, L = largest dimension of either measuring horn or transmitting EUT antenna).

3. Measurements of frequency stability

The frequency stability of the EUT under normal and extreme test conditions is measured in CW-mode (unmodulated).

Frequency measurements are performed under normal test conditions (normal power supply voltage and normal temperature).

Then the test is repeated with extreme test conditions. For extreme test conditions the EUT is placed in a climatic chamber where the front door is made of stable polystyrene. The EUT can radiate through the front door without any additional path losses. The climatic chamber together with the EUT is cooled down to -20 ºC for 1 hour. Then frequency and power density measurements are carried out with power supply set to minimum and maximum values.
The climatic chamber together with the EUT is warmed up at a rate of + 1ºC/minute. During warming-up time the frequency stability and the eirp is monitored constantly. After 2 hours the temperature stability at 50 ºC is reached. Then frequency and power density measurements are carried out with minimum and maximum power supply.

4. Measurements of field strength and power density at spurious frequencies

Spurious frequencies are produced by transmitter and receiver when the EUT is active. The radar unit under test provides different operation modes:
- in motion: medium range mode, long range mode, medium and long range mode
- not in motion: medium range mode, transmission suppressed (transceiver disabled).
In order to avoid measuring errors in power levels caused by very short sweep times, the sweep of the EUT is stopped as certain frequencies.
According to FCC requirements 15.209 and 15.255, spurious emissions have to be investigated as maximum field strength values in the frequency range from 9 kHz to 40 GHz, and as maximum power density in the frequency range above 40 GHz up to 240 GHz. Where possible, the measurement distance shall be 3 m.

In the low frequency range (9 kHz to 30 MHz), the receiving antenna is an active loop antenna which is positioned at 3 m distance in a shielded, anechoic chamber. In case of required measuring distances greater than 3 m, a distance correction factor is used to calculate the received field strength.

Spurious field strength measurements in the frequency range 1 to 12(18) GHz are carried out in shielded semi-anechoic test chambers. The measurement distance is 3 m.

In the frequency range 18 to 240 GHz, spurious field strength measurements are performed in a certain test laboratory environments with rectangular SGH´s. The test distance is 3 m for tests up to 40 GHz.

In the frequency range 40 to 240 GHz, spurious frequencies are measured as power densities. The EUT is operating with its specified modulation. The RBW and VBW are set to such a value that spurious power levels are clearly readable above the fundamental noise level of spectrum analyzer. The measurement distance is chosen up to 0.125 m, depending on the test system noise floor for detecting spurious emission signals.

5. Measurements of maximum safe level for radiated power density

According to FCC § 1.1307, § 1.1310, § 2.1091 and § 2.1093 measurements are carried out in order to evaluate the impact of human exposure to RF radiation. For this test the EUT is in normal operation mode: QPSK modulated.

There is a safety distance of 2m given in the manufacturer's document: "Installation and user manual SL60-100-57/64-38-E-O".

The maximum peak power density PD in r = 3 m distance is determined as

1.02 [µW/cm^2] (see plot 1e, Chapter 5.4 Power Density §15.255(b)(1))

Peak Power (EIRP) $EIRP = PD * 4\pi * r^2 = PD * 1130973.4\ cm^2$
$EIRP = 1.154\ W$

Limit of maximum ERP (EIRP) for frequencies above 1.5 GHz is 3 W (4.9W). See FCC § 2.1091
(eirp = erp + 2.15 dB, EIRP = ERP x 1.64).

RF Exposure at 2 m distance from EUT

$PD = EIRP / (4\pi * r^2)$
$PD = 0.0023\ mW/cm^2 = 0.023\ W/m^2$

Limit of maximum permissible exposure (MPE) for uncontrolled environment:1.0 mW/cm². See FCC § 1.1310.