Summary of Emissions Testing for "Cell Phone Detector"

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Summary of Emissions Testing for "Non-Linear Junction Detector"

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Overview:
The objective of these measurements is to perform an initial evaluation of the "Non-linear junction detector" (NLJD) and to determine the electromagnetic field levels radiated by the device. The primary application being assumed for the NLJD is that of detecting contraband cell phones.

Status of the Device:
The basic operation is as described in the short user manual. When operating, the NLJD generates a relatively strong single tone signal at approximately 848 MHz. This signal is radiated by the antenna at the end of the boom. From preliminary measurements it appears that this antenna is close to circularly polarized (results shown later). This makes the operation of the NLJD relatively insensitive to the orientation of the device it is being used to detect – interrogated device (ID)- (e.g. cell phone). When these strong fields are applied to a solid state junction they tend to drive the junction into its non-linear region resulting in the generation of harmonic frequencies at 2x848 MHz (2^{nd} harmonic) and 3x848 MHz (3^{rd} harmonic). These harmonic frequency signals are often radiated by the interrogated device. The NLJD is tuned to receive signals at the 2^{nd} and 3^{rd} harmonic frequencies, thereby detecting the presence of any radiating non-linear junction. Since the applied fields are so large, it is not necessary that the ID is powered or turned on for the NLJD to detect its presence. In an anechoic test chamber the NLJD is able to begin detecting a cell phone that is turned off at a range of approximately 2.5-3 meters. Certainly, when within 1 meter of the cell phone the NLJD registers a strong response. It is important to note that the NLJD response is not specific to cell phone junctions, but rather any non-linear junction. Hence, the NLJD registers a response to most electronic devices and equipment that are within its range.

However, the NLJD unit under test has a number of issues that affect its performance

- When completely drained, it appears that the battery cannot be charged by the charging unit (CU) provided with the NLJD. However, when battery is

removed from its enclosure and charged by a separate 6V charger the battery retains the charge and seems to accept charging from the CU.

- There appears to be at least one faulty connection in the antenna boom (AB). This faulty connection causes intermittent performance, specifically making it difficult to turn the unit on and change its state with the buttons on the control panel on the AB. This problem is exacerbated when the boom is extended. Therefore, all the subsequent results were obtained with the boom in its fully compressed state. No attempt was made to disassemble the boom to find the faulty connection.

- It is also possible that the control panel buttons do not operate reliably. This could also be a contributor to the difficulty associated with turning the unit on and changing its state.

Radiated Field Levels

The first field tests are to determine the compliance or noncompliance of the NLJD with the FCC part 15 requirements for an unlicensed intentional radiator. According to the FCC 15.209 regulation, an unlicensed intentional radiator operating in the 806-890 MHz frequency range cannot radiate an electric field that exceeds 200 μV/m at a distance of 3 meters from the unit.

The test set up is shown in Figure 1.

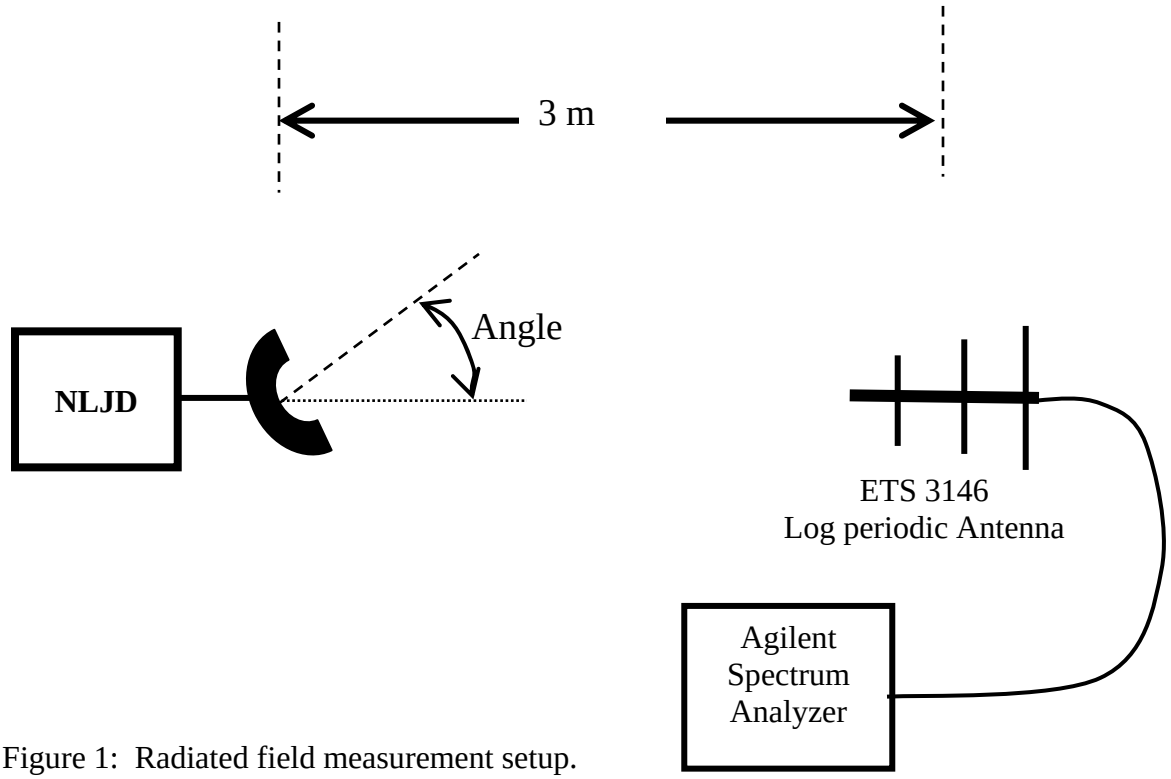
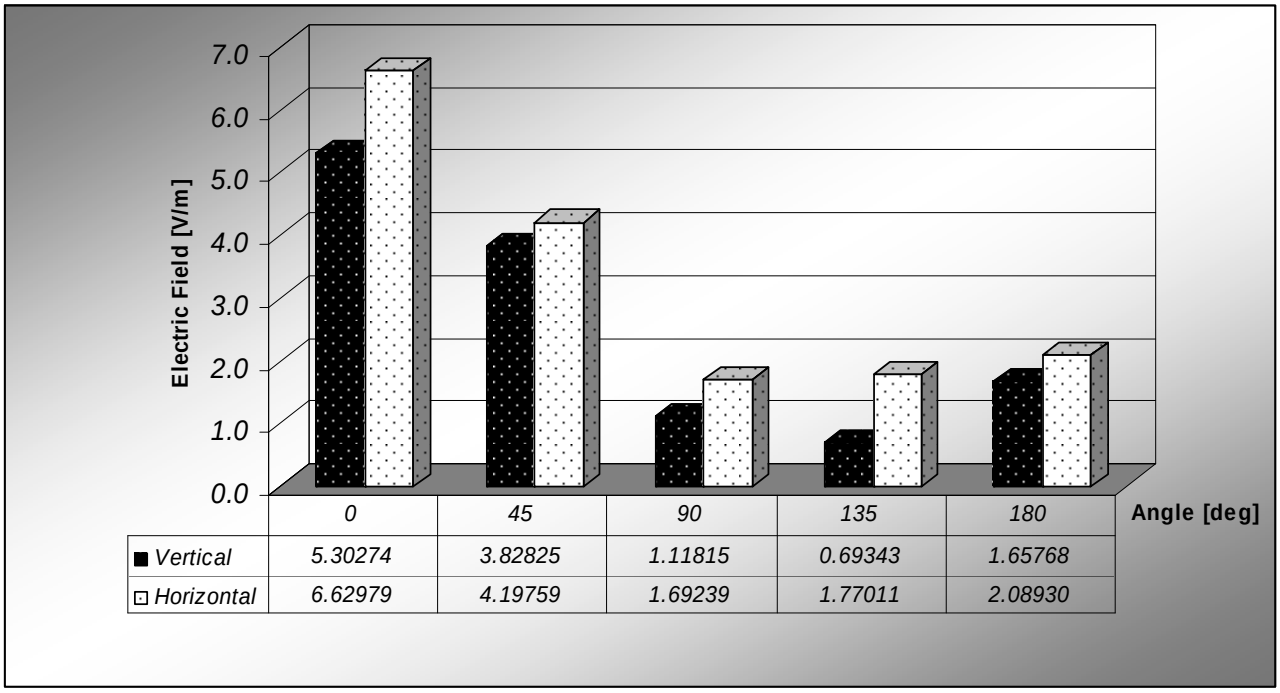


Figure 1: Radiated field measurement setup.

In this setup, a calibrated spectrum analyzer was used and the effects of loss and the antenna factor associated with the connecting cabling and test antenna were removed (deembed) from the measured data. The resulting calibrated electric field measurements are given in Figure 2.



	0	45	90	135	180
■ Vertical	5.30274	3.82825	1.11815	0.69343	1.65768
⊡ Horizontal	6.62979	4.19759	1.69239	1.77011	2.08930

Figure 2: Calibrated electric field measurements as a function of NLJD orientation (angle and alignment).

These result clearly show that the field levels radiated by the NLJD far exceed the maximum allowable FCC limits for unlicensed devices. Hence, the NLJD will have to be licensed.

These results also show that the vertical and horizontal polarized fields radiated by the NLJD antenna are nearly equal (antenna is nearly circularly polarized), with the horizontal fields being slightly stronger. The beamwidth of the main radiation pattern is approximately 90^{o}. The broad pattern and significant radiation outside the main beam of the antenna suggest that the NLJD will be susceptible to registering a response to non-linear junctions that are not within the main beam direction. This has been observed in the tests.

The NLJD has three power settings. All the measurement results shown use the maximum output power level. The other settings are nominally 5 dB and 10 dB below the maximum. However, tests have shown that these lower level settings are not very accurate. The 5 dB setting is approximately 3.5-4 dB and the 10 dB setting is approximately 5-7 dB.

The final measurements to be presented are near-field electric field levels to ascertain the radio frequency exposure the operator of the NLJD is subjected to. Currently there are no federal regulations for RF exposure. However, there are several recommended standards. The most commonly used standards are the FCC standard, the IEEE C95.1-1999 standard, and the International Council on Non-Ionizing Radiation Protection (ICNIRP) standard, which is the standard used throughout Europe and most other countries outside North America. These are shown in Figures 3, 4, and 5.

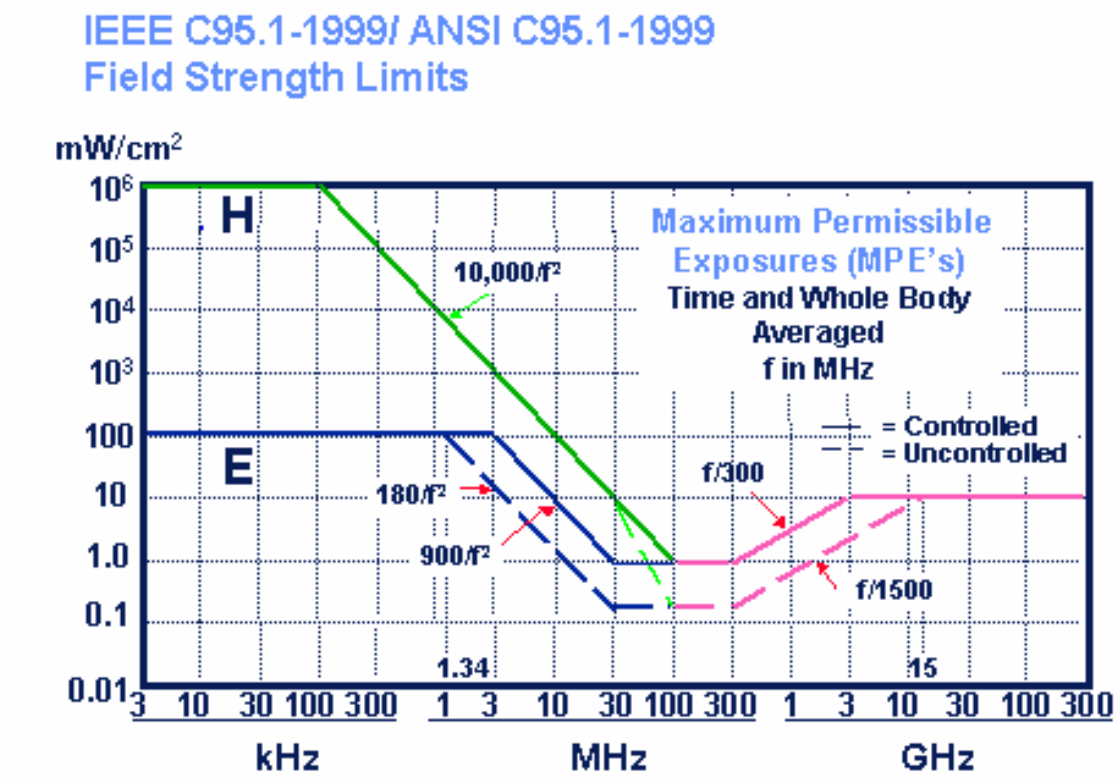


Figure 3: IEEE C95.1-1999 field exposure standard

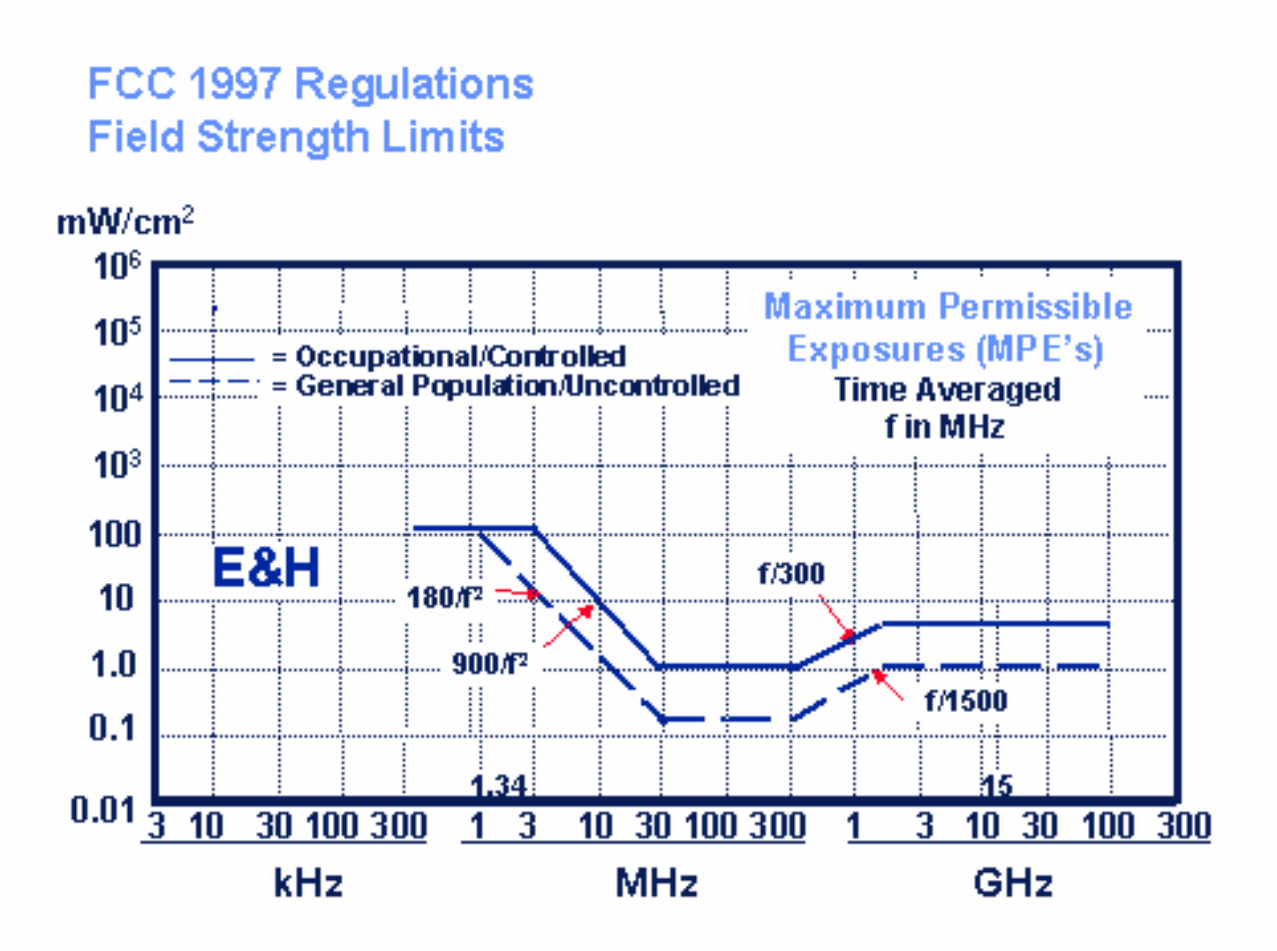


Figure 4: FCC field exposure standard

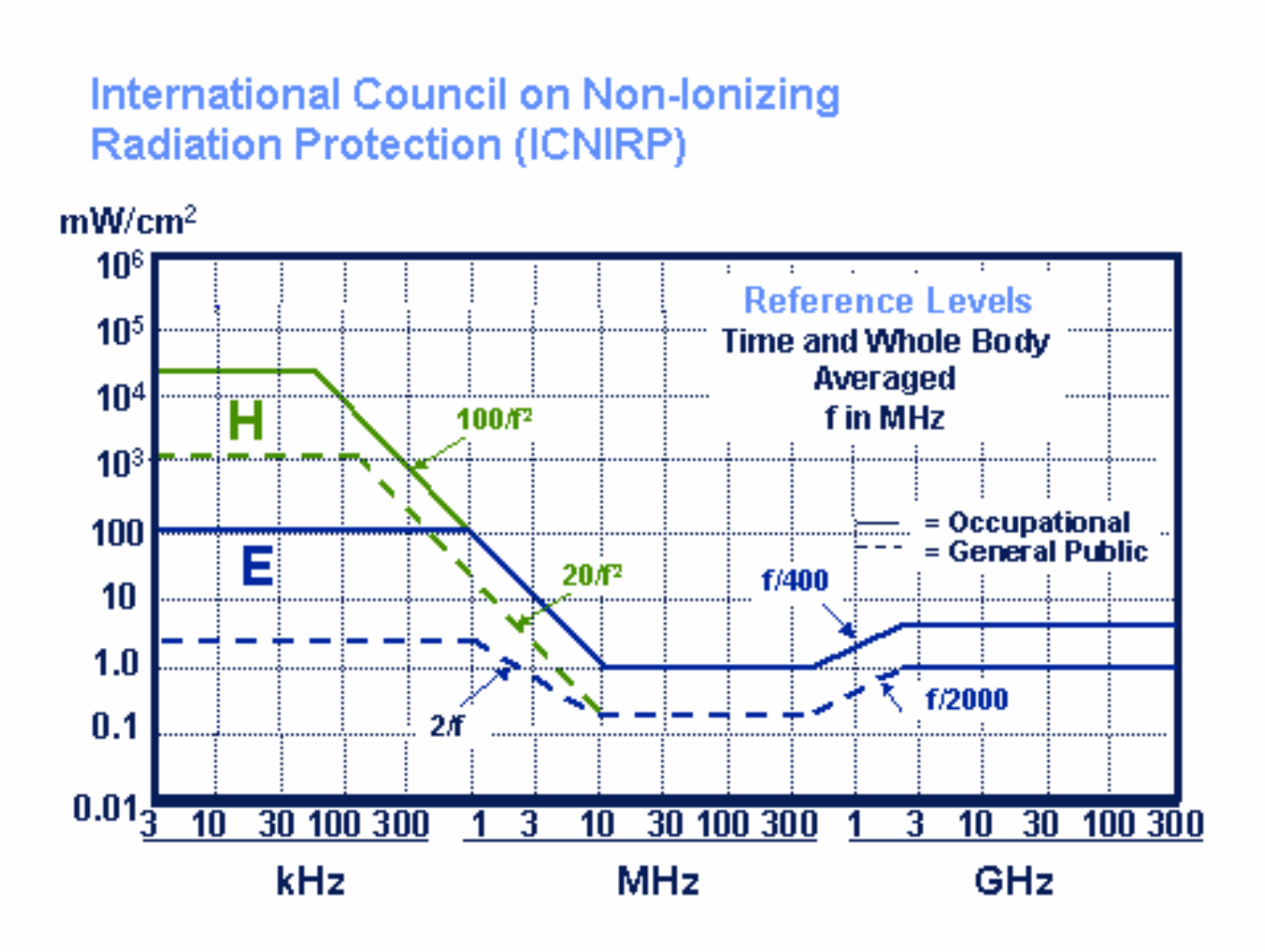


Figure 5: ICNIRP field exposure standard

At 848 MHz, the FCC and IEEE standards are the same. For the uncontrolled population, that is for individuals are not in an environment that has an approved RF safety program, the maximum electric field exposure is approximately 46 V/m (0.57 mW/cm^2). The field level from the ICNIRP standard is slightly smaller.

A triple axis near-field electric field probe was used to measure the field levels near the antenna and boom. The maximum field level that this probe can measure is 30 V/m. The locations where near-field measurements were made are shown in Figure 6. The measured electric fields are given in Figure 7.

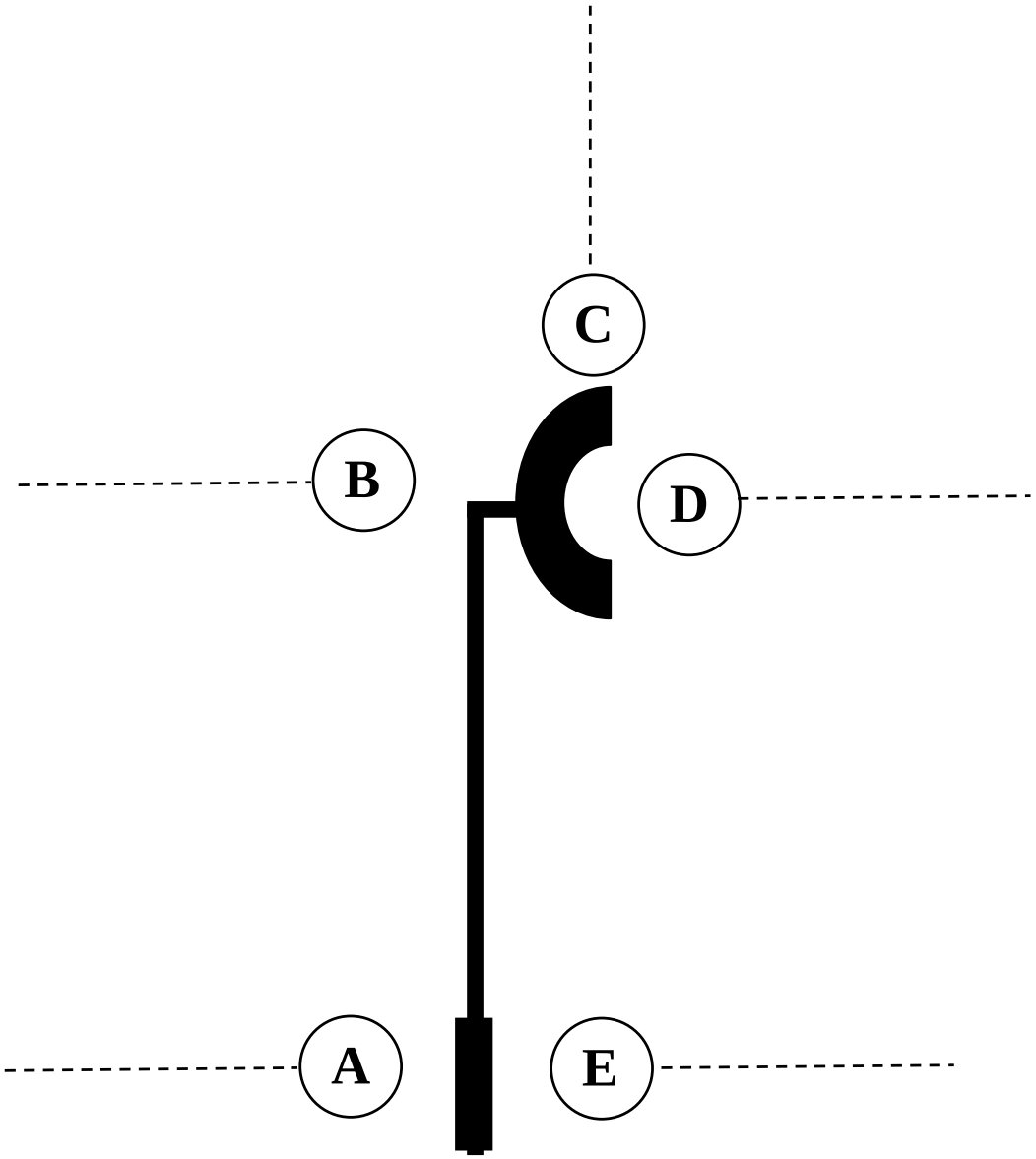


Figure 6: Location of near-field measurements around antenna boom.

	A	B	C	D	E	**Location**
10 cm	1.7 V/m	1.7 V/m	15 V/m	>30 V/m	5 V/m	
30 cm	0.7 V/m	1.5 V/m	7 V/m	30 V/m	7 V/m	
50 cm			2.5 V/m	26 V/m	8 V/m	
Distance						

Figure 7: Near-field electric field measurements around antenna boom.

It is apparent from the results in Figure 7 that the field levels around the antenna and boom are below the accepted exposure limits, except directly in front of the antenna less than 30 cm from the antenna surface.