Envelope Sampling of Pulsed Signals (Radar)

ar europe

MICRORAD

percipere, aestimare et inquirere

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TOPICS

- Microrad - AR
- CEI (CENELEC) Standards
- Pulsed Signal: Radar
- Measurement Systems
- Wideband Solution
- Block Diagram and Sensor type
- Ispra-Microrad
- Fraunhofer zone;
- Narrowband and Wideband measurements
- Conclusion
- Bench Test
- Roadmap

MICRORAD - AR

MICRORAD was founded by Mr. Roberto Ruggeri in 2000. The first products developed and launched were a series of HT300 dosimetric meters and monitoring devices designed to measure the exposure of humans to low frequency (50Hz to 100KHz) magnetic induction fields. These instruments are used on a very wide scale by the Italian Environmental Agency (ARPA) and by health physics departments within hospitals.

More recently the company has expanded its product range to incorporate specific instruments in the area of Electromagnetic Safety (EMS).

AR and Microrad have established recently a partnership in the Safety Market.

State of the Art

- The boradband meters mesaure the RMS value of the field , assuming it as a CW signal generated by sinusoidal source.
- Our target is to measure CW signals as well as pulsed signals, specifically the fields generated by radars.
- In this presentation I refer to a field tests made in italy in two different sites, Fiumicino airport, in Rome and Firenze Peretola airport, in Florence.

Standard - CEI 211-7/B

- Italian standard CEI 211 – 7/B:
  - Guide for the measurement and the evaluation of electromagnetic fields in the frequency range 10 kHz - 300 GHz with reference to the human exposure.
  - **Appendix B**: Measurements and evaluation of the electromagnetic fields generated by radar systems

➢ This guide provides three different systems for this type of measurement, as well as the main technical parameters to be measured

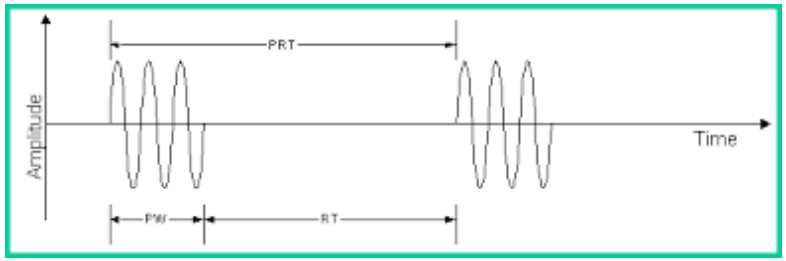
- ➢ B.8 Procedures for measuring the electromagnetic field
- ➢ B.9 Examples of measurement of the electromagnetic field

Standard - CEI 211-7/B

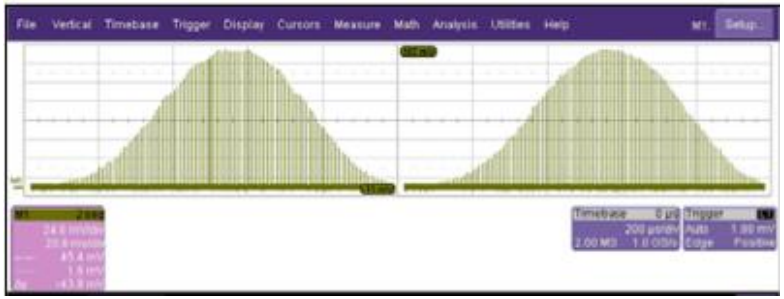
Measurement System	Strength	Weakness
Spectrum Analyzer	– measurement all parameters of the radar signal – possibility to easily tracking between the measured and the reference samples – wide frequency range for all possible measurement requirements	– quite expensive – heavy and high size – maximum RBW less than the required value for a correct meaurement – Set up longer than other systems
Oscilloscope	– easy to use – not so expensive	– narrow sensitivity
Field Meter	– easy to use – not so expensive – measurement not affected by both the polarization and the direction of propagation of the field	– narrow sensitivity – Peak value available only using the duty cycle of the radar – Frequency not available (Time domain)

Pulsed Signals: Radar

Typical parameters of a Radar:



- Pulse Width (PW) = τ
- Pulse Repetition Time (T_{rep})



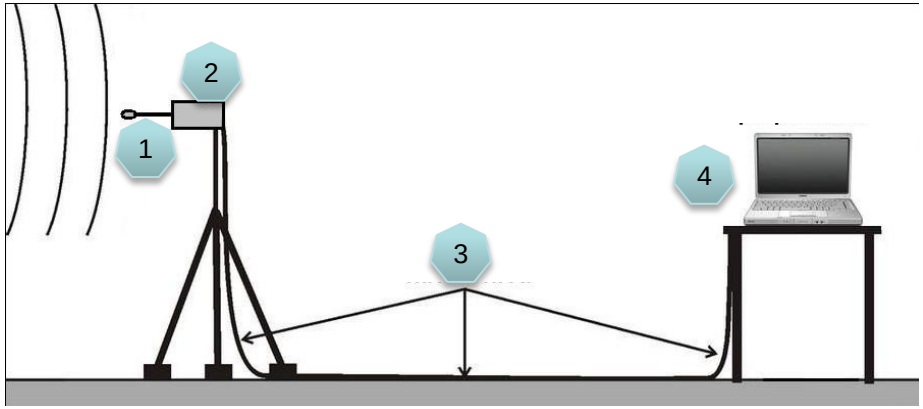
- Antenna Rotation Time (T_{rot})
- Illumination Time (T_{ill})

- Peak electric field value (E_{peak})

- Average electric field value $E_{avg} = E_{peak} \times \sqrt{\frac{t}{T_{rep}}} \times \sqrt{\frac{T_{ill}}{T_{rot}}} =$

Measurement Systems

WIDEBAND SOLUTION



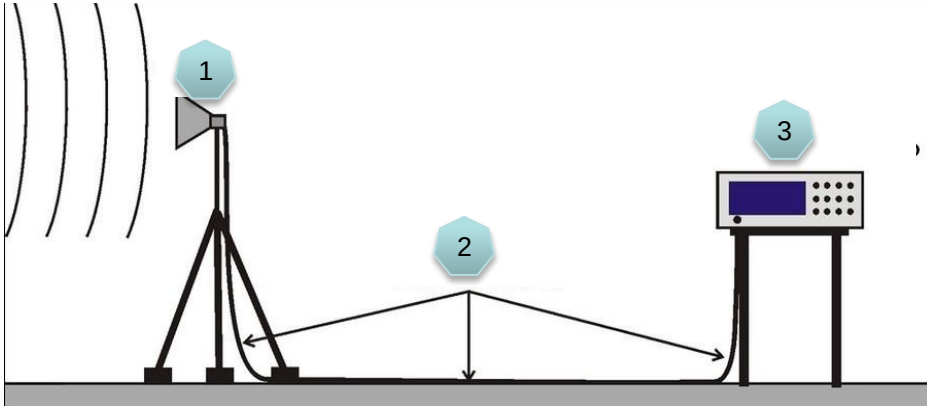
1 = Isotropic broadband probe
(resistive dipole and diode detector) mod. RP01 (2÷3GHz)

2 = Microrad high dynamic envelope sampler mod. NHT-3DR

3 = Fiber Optical Cable

4 = Notebook equipped with Microrad application software mod. Waves

NARROWBAND SOLUTION

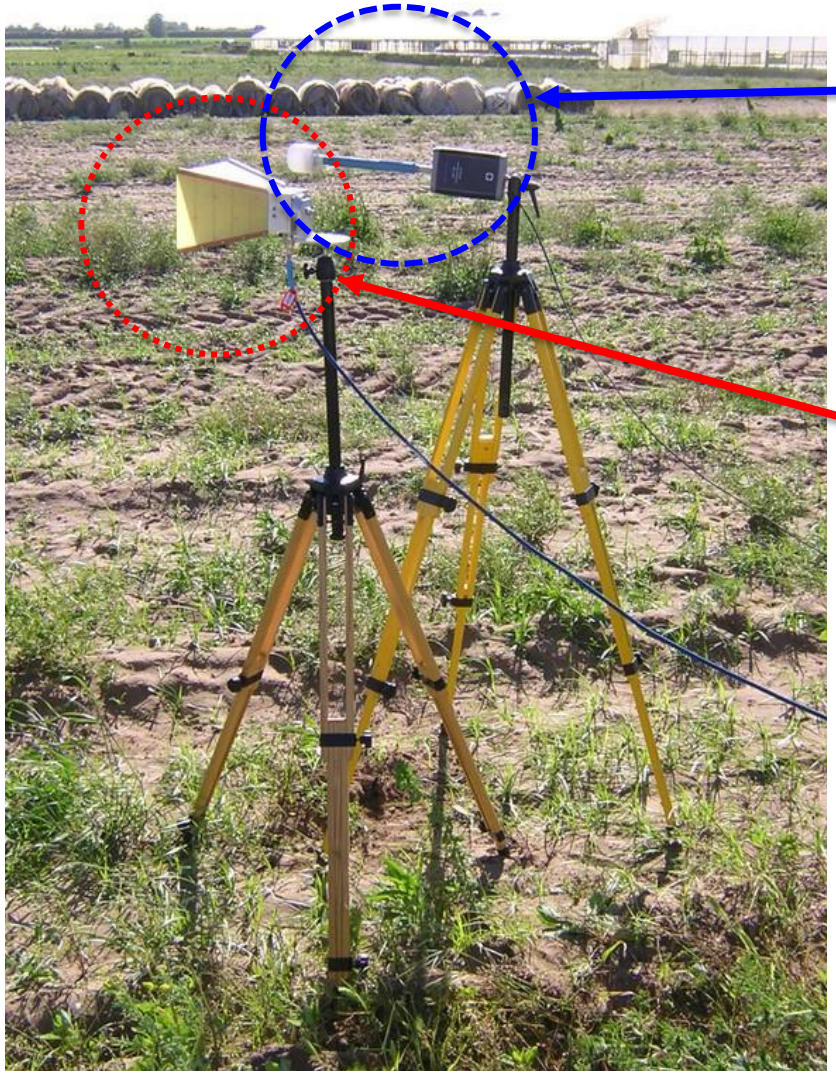


1 = ETS Horn Antenna mod. 3115 (750MHz ÷ 18GHz)

2 = Suhner Coaxial Cable mod. Sucoflex 102A

3 = Rohde&Schwarz Spectrum Analyzer
mod. FSP30 (9 kHz – 30 GHz)

Field Test



WIDEBAND SOLUTION (MICRORAD)

NARROWBAND SOLUTION (ISPRA)

The Institute for Environmental Protection and Research, ISPRA (Istituto Superiore per la Protezione e la Ricerca Ambientale).

Wideband Solution

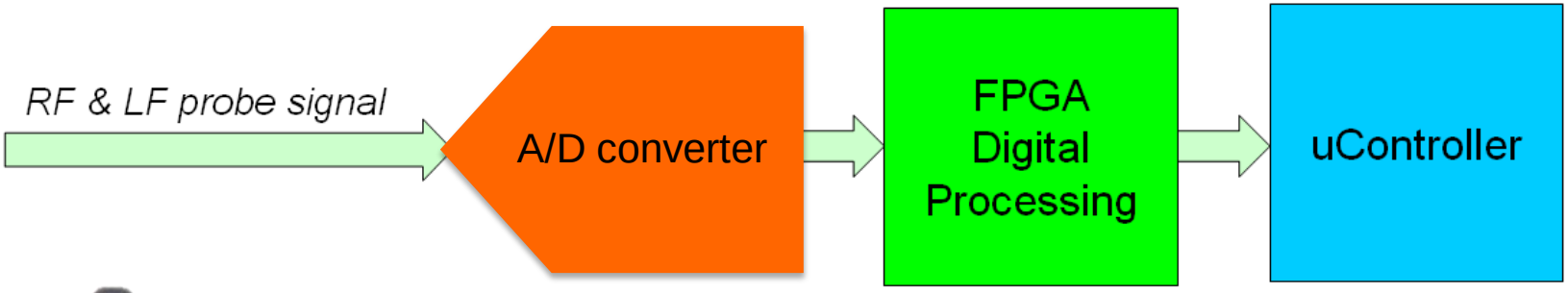
- ✓ In the case of multiple sources, with a broadband meter it is not possible to discriminate between the various frequencies transmitted under their individual peak value;

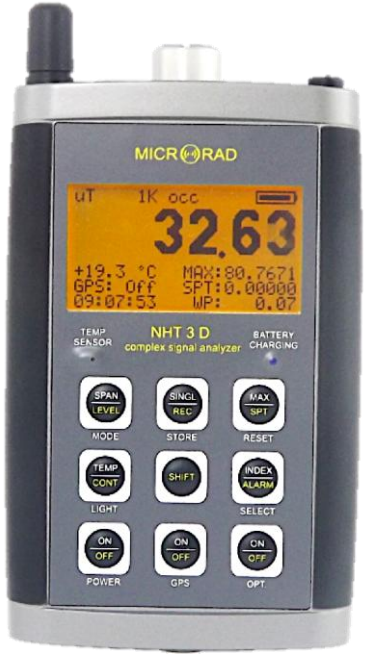
- ✓ Therefore, the measured value is derived from the combined frequencies of the radar test which includes all possible sources including in the frequency band of the probe in use.

- ✓ From a safety point of view, a measurement with the field strength meter that falls within the peak and RMS is definitely safe; in the event of a violation of one or both of the limits is necessary to proceed with other tools to assess the contribution of each source.

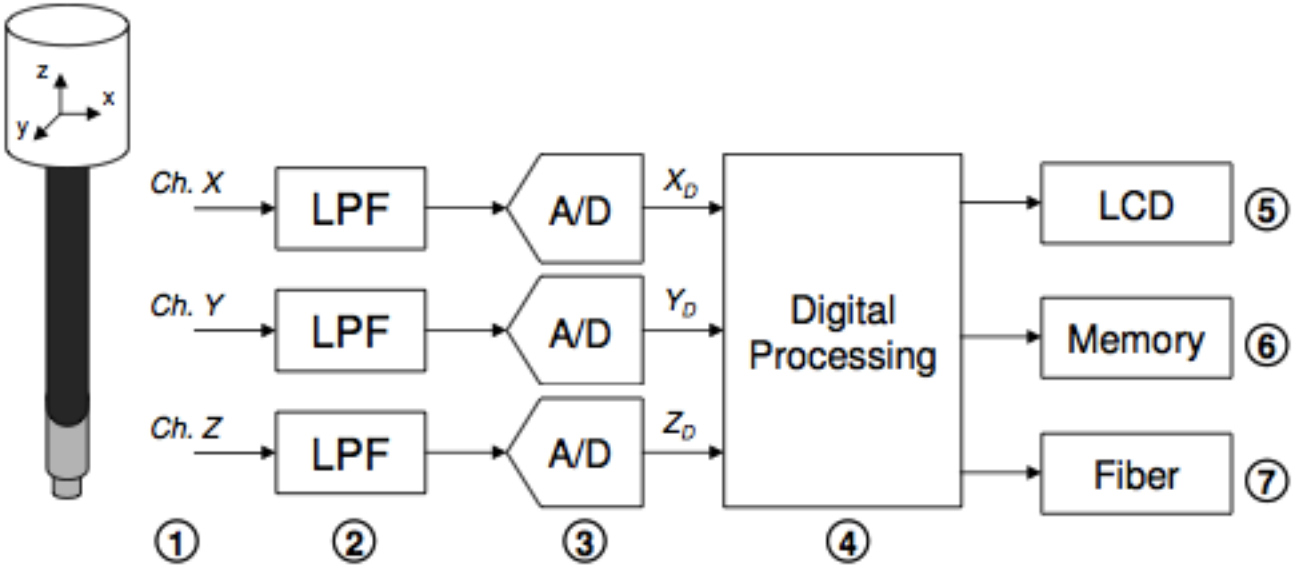
Wideband Meter: NHT 3D

NHT-3D Measurement Signal Path



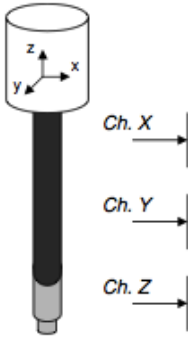


Block Diagram



1. Analog signals from a three axes isotropic probe for electric or magnetic field meausurements
2. Low pass Filter (Anti-Aliasing)
3. Analog to Digital converters
4. Digital Processing
5. Display (LCD)
6. Non volatile Storage memory (EPROM)
7. Optical Fiber Communication

Sensor Type



Sensor Type: diode dipoles;

The probes is based on a dipole connected to the detector;

The path detector-meter is low impedence;

This signal is the input for the sampler for plotting the envelope;

High dynamic range (> dynamic range of thermocoupler sensors) >= 60dB;

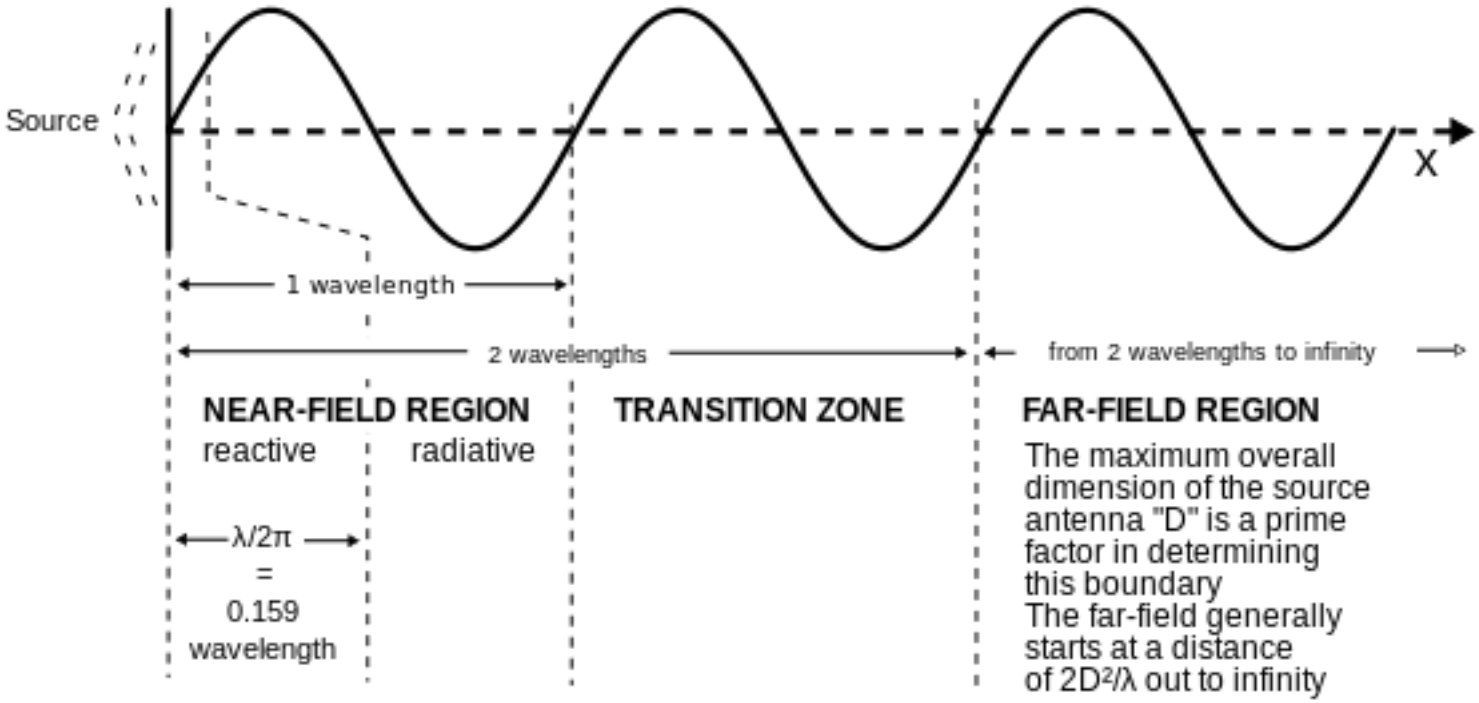
Joint survey ISPRA-Microrad

The purpose of this test was to establish if there is congruity between measures obtained with wideband system and measures obtained with traditional narrowband equipment (spectrum analyzer plus horn antenna).

The measurements that have been conducted at the same time using both systems above mentioned, have allowed us to evaluate the effectiveness of such new measurement equipment.

The distance between the radar and the measurement point is 1116mt in the case of Peretola and 508 mt in the case of Fiumicino (**Far Field**).

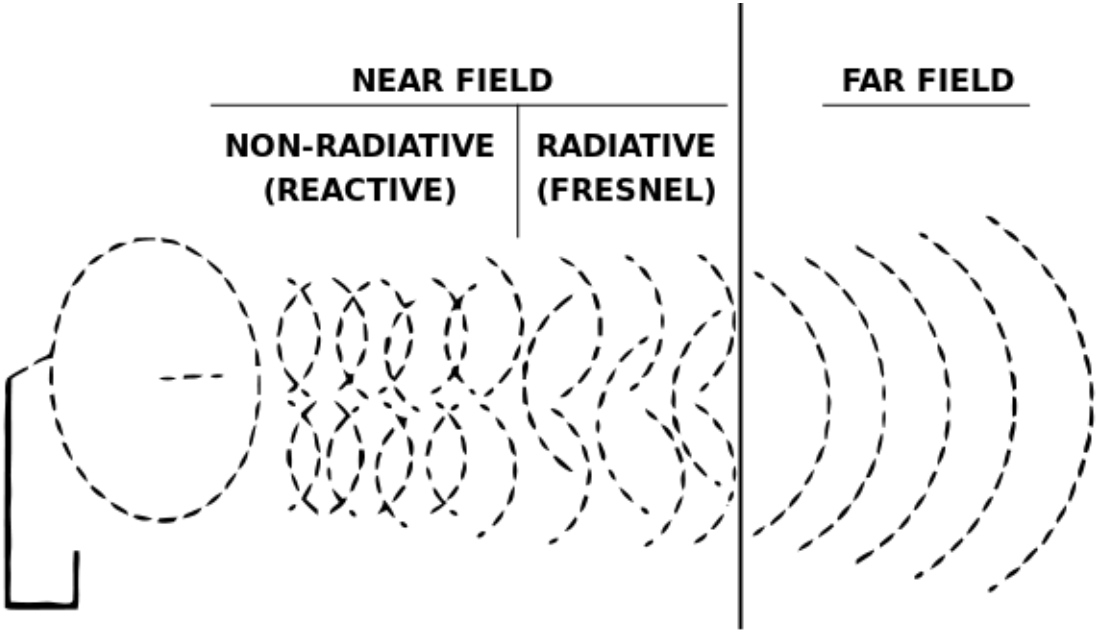
Fraunhofer Zone



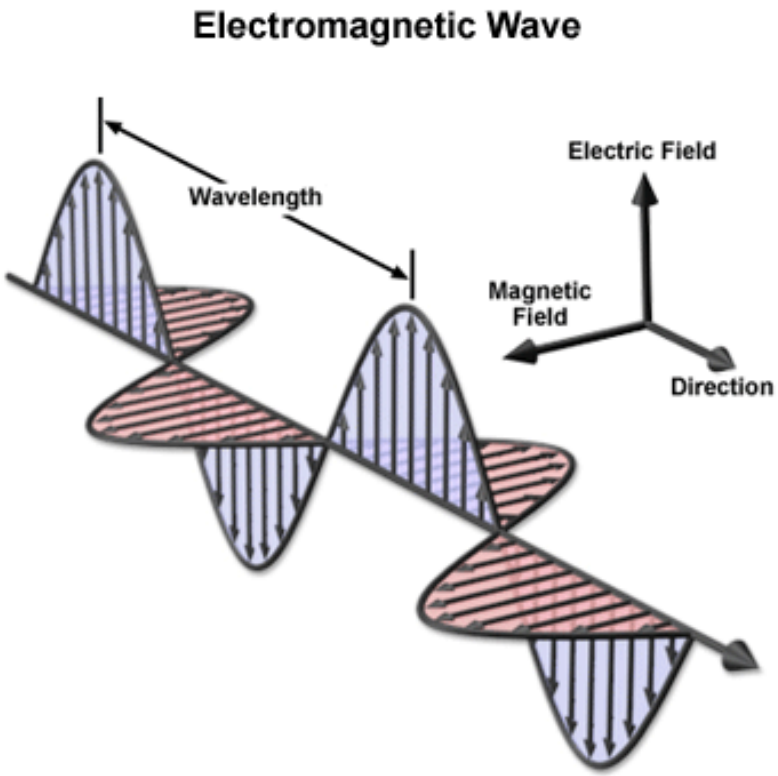
Near Field Region

<u>Electromagnetically short antennas</u>

In all such antennas, the short length means that charges and currents in each sub-section of the antenna are the same at any given time, since the antenna is too short for the RF transmitter voltage to reverse before its effects on charges and currents are felt over the entire antenna length.



Far Field Region



Electromagnetically long antennas

For antennas physically larger than a half-wavelength of the radiation they emit, the near and far fields are defined in terms of the Fraunhofer distance. The Fraunhofer distance, named after Joseph von Fraunhofer, is the value of:

$$d_{\mathrm{f}} = \frac{2D^2}{\lambda},$$

where D is the largest dimension of the radiator (or the diameter of the antenna) and λ is the wavelength of the radio wave. This distance provides the limit between the near and far field. The parameter D corresponds to the physical length of an antenna, or the diameter of a "dish" antenna.

Narrowband Measurement

Narrowband measurement system - result

Radar frequencies:

f_1 = 2.734,4MHz; f_2 = 2.815,2MHz; f_3 = 2.855,2MHz;

Antenna rotation period: T_{rot} = 3,78 s

Illumination period: T_{ill} = 14,8 ms;

Pulse repetition period: T_{rep} = 1,11 ms;

Pulse durations (2):

Their durations, indicated respectively as τ_1 and τ_2, are:

τ_1 = 98 μs

τ_2 = 9,9 μs

Peak electric field value:

E_{peak} = 2,3 V/m

Average electric field value: $E_{avg} = E_{peak} \times \sqrt{\frac{t}{T_{rep}}} \times \sqrt{\frac{T_{ill}}{T_{rot}}} = 45$ mV/m

Broadband Measurement

<u>Broaband measurement system – result</u>

Antenna rotation period: T_{rot} = 3,8 s

Illumination period: T_{ill} = 14,8 ms;

Pulse repetition period: T_{rep} = 1,1 ms;

Pulse durations (2):

Their durations, indicated respectively as τ_1 and τ_2, are:

τ_1 = 100 μs

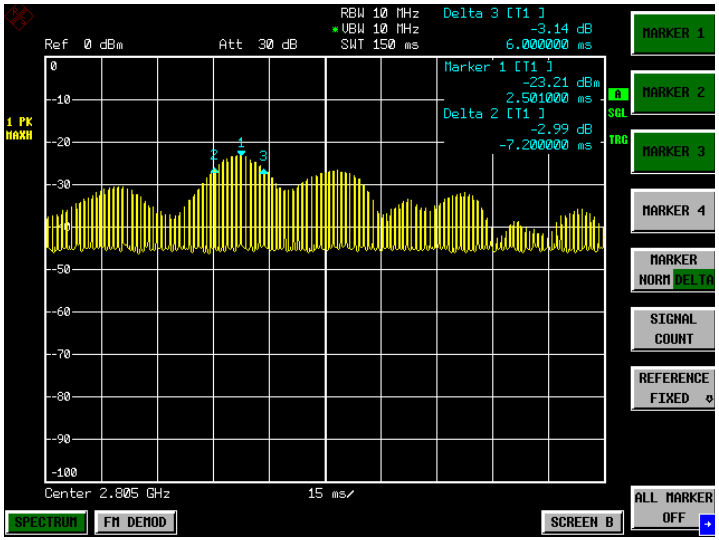
τ_2 = 10μs

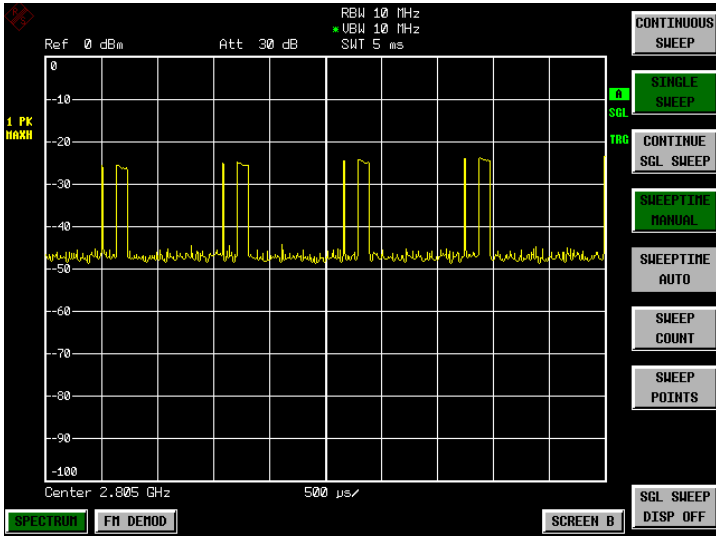
Peak electric field value:

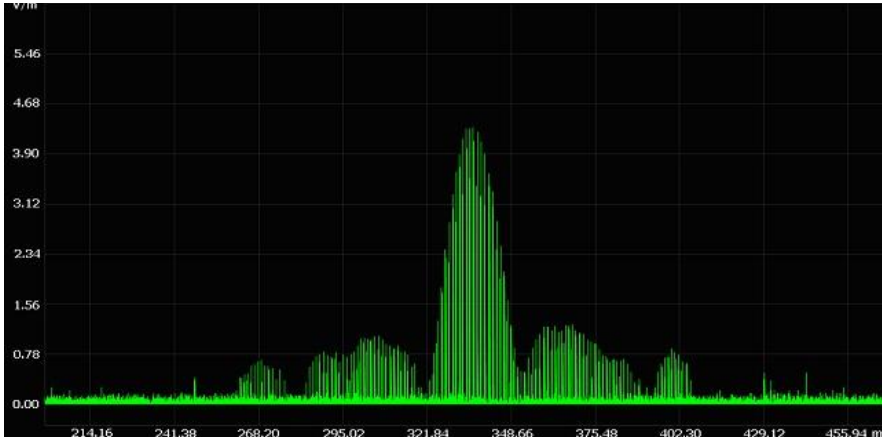
E_{peak} = 2,65 V/m

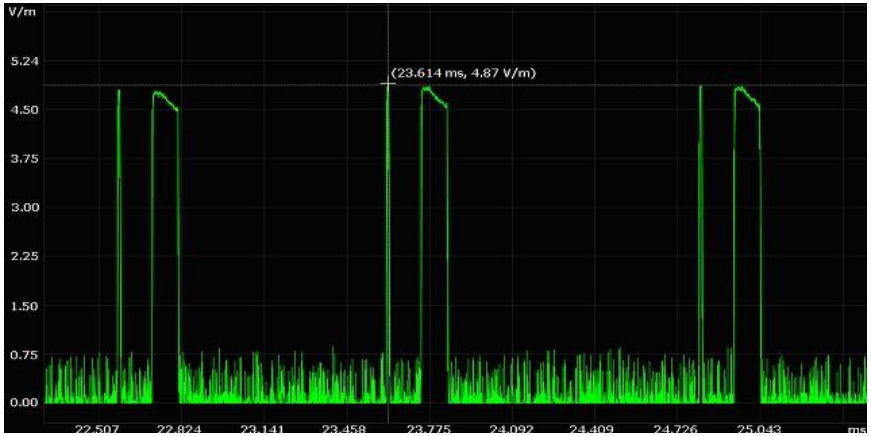
Average electric field value: $E_{avg} = E_{peak} \times \sqrt{\frac{t}{T_{rep}}} \times \sqrt{\frac{T_{ill}}{T_{rot}}} = 51$ mV/m

Screenshots









CONCLUSION (ISPRA)

- The results reported in the previous slides show a good concordance between measures obtained with the narrowband measurement system and measures obtained with the Microrad broadband sampler measurement system.

- The differences on the technical specifications of the radar in the time domain are less than 5% while the difference in the peak electric field value is 1,2 dB in the case of Firenze Peretola and 0,03 dB in the case of Roma Fiumicino

- Taking into account all the above considerations, it can be affirmed that, in the analysis of signals emitted by radar systems such as those examined in this survey, the broadband sampler measurement system can be considered a valid alternative to the traditional narrowband measurement chains.

Bench Test

A: PC with Waves software loaded

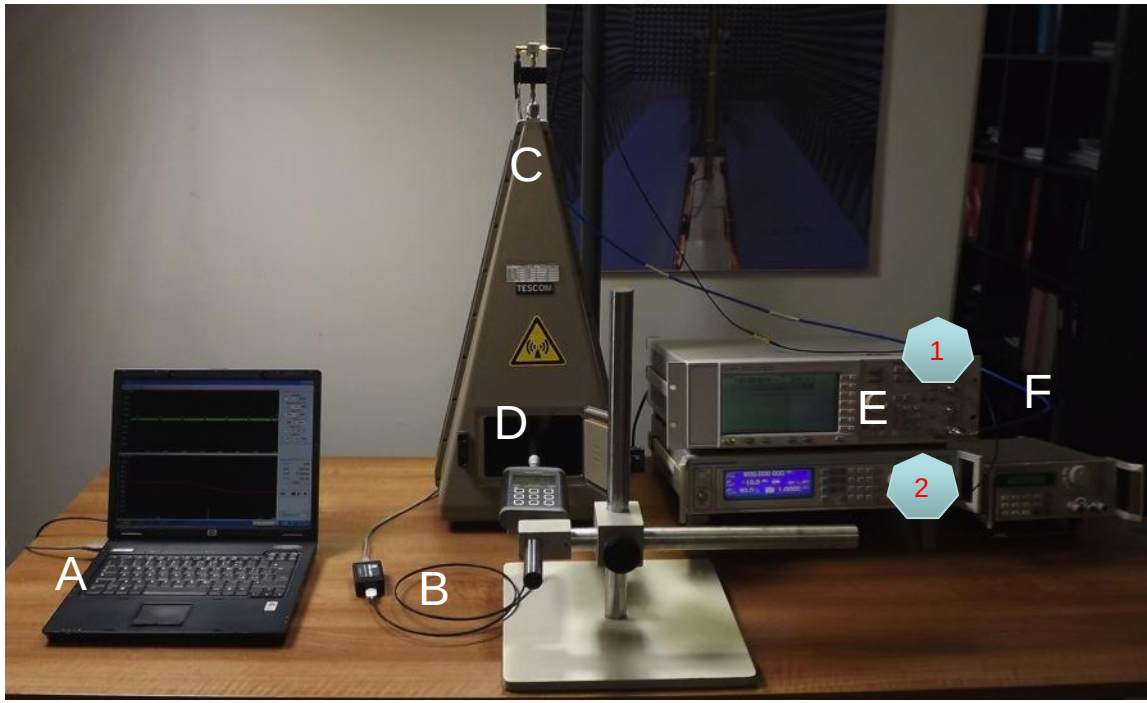
B: Optical Cable and Usb adapter

C: TEM Cell with Splitter/Combiner and Power Amplifier

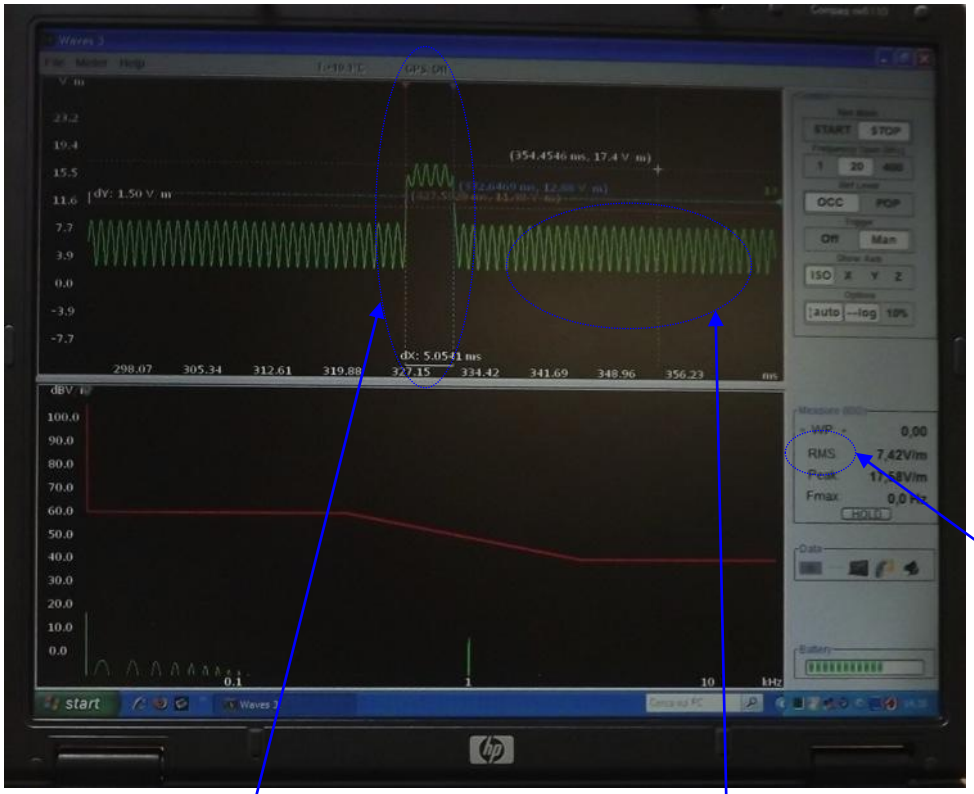
D: NHT 3D and RF Probe

E: Signal Generators 1 2

F: Power Supply



NHT 3D + RF Probe



Form Factor 2

Form Factor 1

<u>Input signals:</u>

Signal generator 2 Pulsed signal:

Freq=1GHz

Pulse lenght = 5ms;

Pulse Repetition Time (PRT) = 100ms

Signal generator 1 Sinusoidal Wave + AM Mod.:

Freq.800MHz

AM Mod. :

Freq. 1kHz

depth 90%

RMS value

The PC screen displays both the signal Form Factors (upper window – time domain) and RMS value;

Roadmap Microrad: NHT 3DR + Probes

- NHT 3DR - RF pulse signal Meter
    - Pulse length: target<300ns

- PROBES for NHT 3DR

QUESTIONS AND ANSWERS

THANK YOU FOR YOUR ATTENTION

Q&A?