"Capacity Building and Strengthening Institutional Arrangement"

Analysis and sampling of air and air pollution

General principles on non-ionizing radiation measurements and equipment (Part 2)

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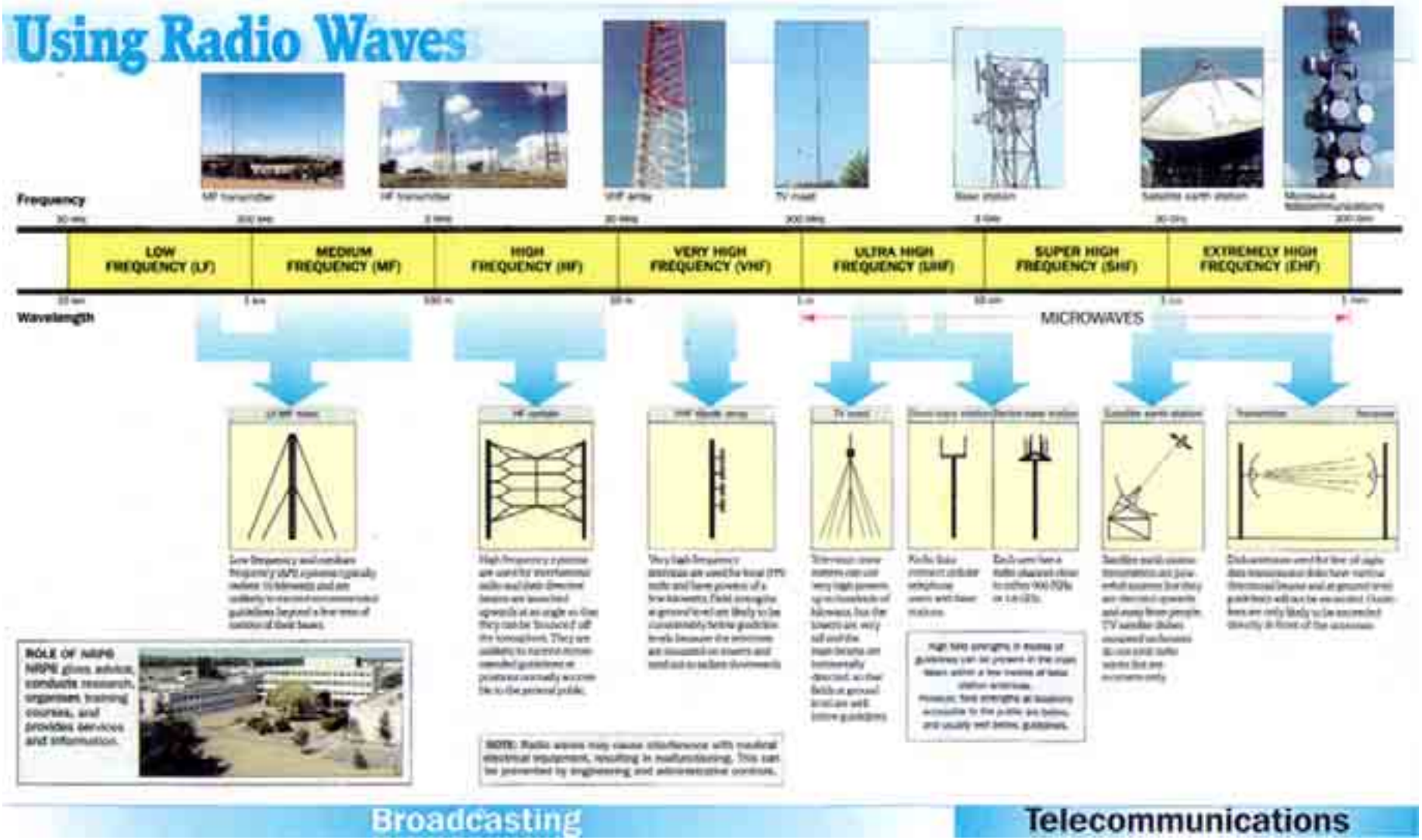
APAT

Agency for Environmental Protection and Technical Service

Units of measure

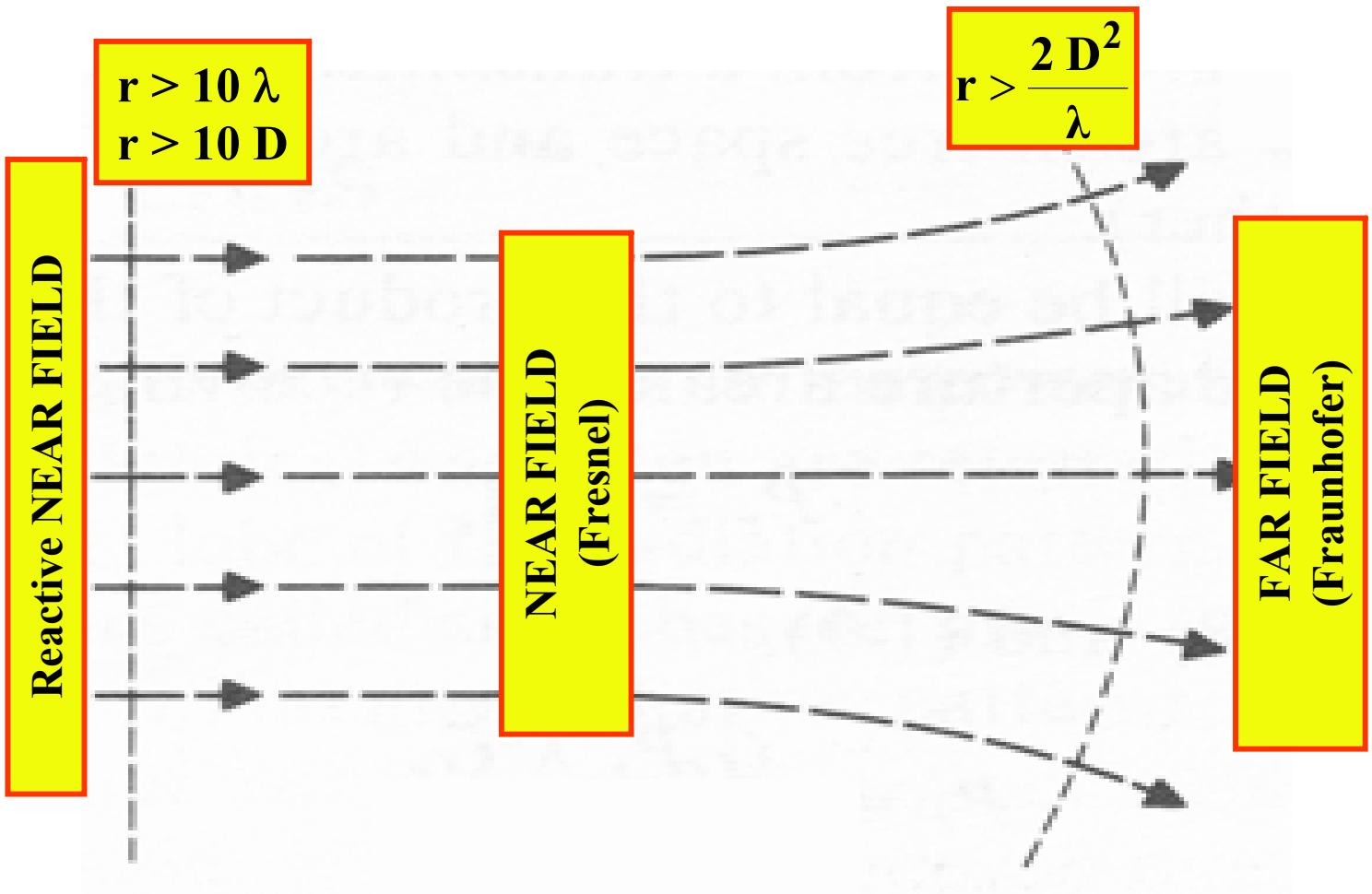
- Electric field **E**: [Volt/meter]
- Magnetic field **H**: [Ampere/Meter]
- Induced magnetic field **B**: [Tesla= Volt*second*meter $^{-2}$= 1 kg · second $^{-2}$ · Ampere $^{-1}$]
- Power density **S**: [Watt/ meter^2]
- Specific Absorption Rate **SAR**: [Watt/kg]
- Current density **J**: [Ampere/meter^2]
- Conductivity **s**: [Siemens/meter]
- Frequency **f**: [Hertz]

Typical antennas



Near and Far Field of a generic source (antenna)

- The surrounding space is divided into three contiguous regions:



Field'Characteristics into the region of reactive near field

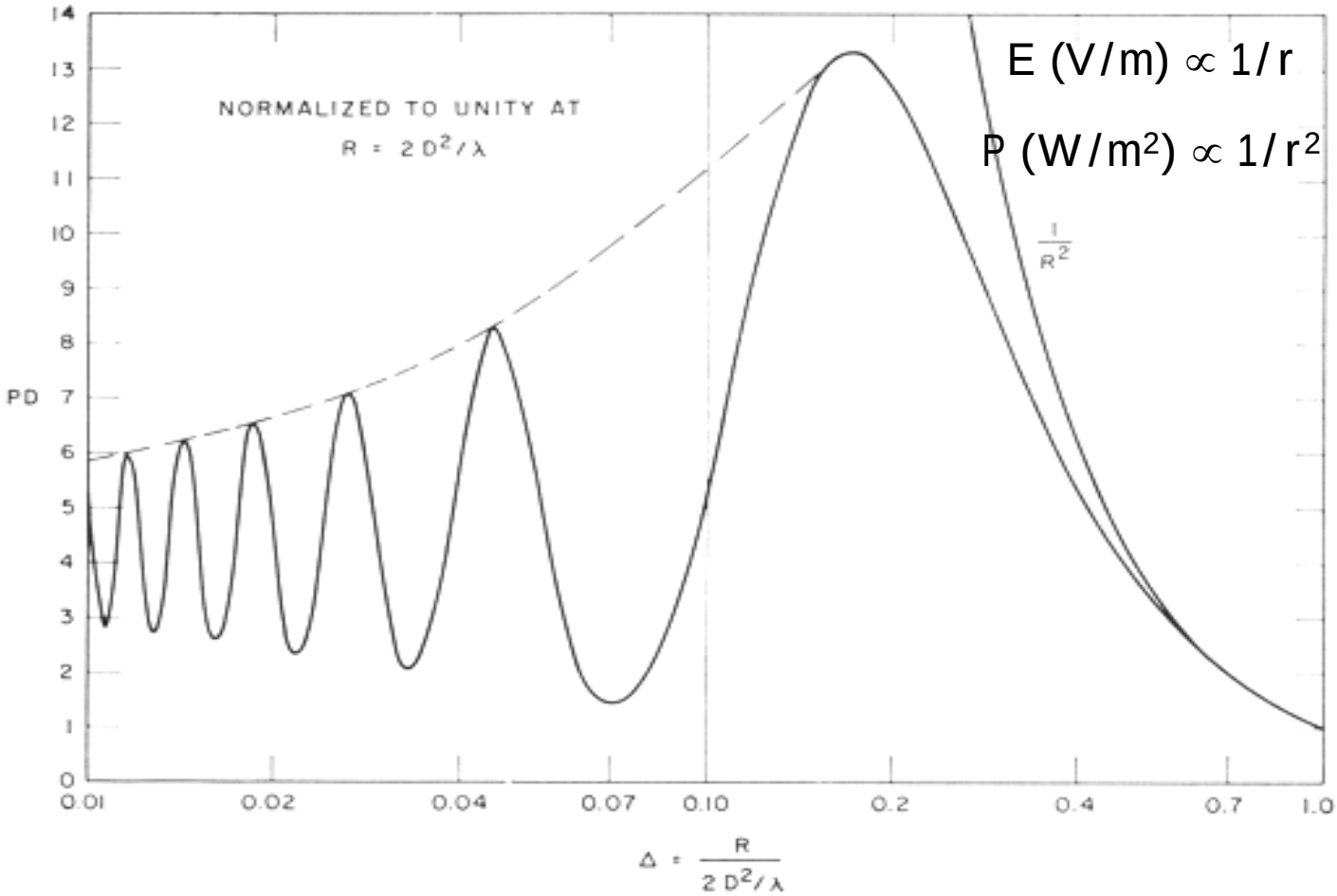
- The electric and magnetic field aren't bound by a relation (by the characteristic impedence of air ζ)
- The presence of an extraneous body would modify strongly the characteristics of antenna cause of the strong coupling

Field'Characteristics into the region of radiative near field

- For antennas not much vast ($D < \lambda$) this region doesn't exist (the field passes from the reactive near field to the far field, like the case of hertzian dipole)

- The electric and magnetic field are bound by the characteristic impedence of air ζ (a costant)

Typical trend of field into the region of radiative near field



Field'Characteristics into the region of far field

- The electromagnetic field has the characteristics of a non uniform spheral wave (for high distances, local flat wave)
- The electric and magnetic field are bound by the characteristic impedence of air ζ

Different Measurements Modalities

Measurements on broad band

They provide with indications about the total (integral) effective value (RMS) of field in the measure point

☺ They are simple and cheap;

☹ There aren't indications about single contrbutions in frequency;

☹ It's difficult to extrapolate protective values of field (the highest achievable values).

Measurements on narrow band

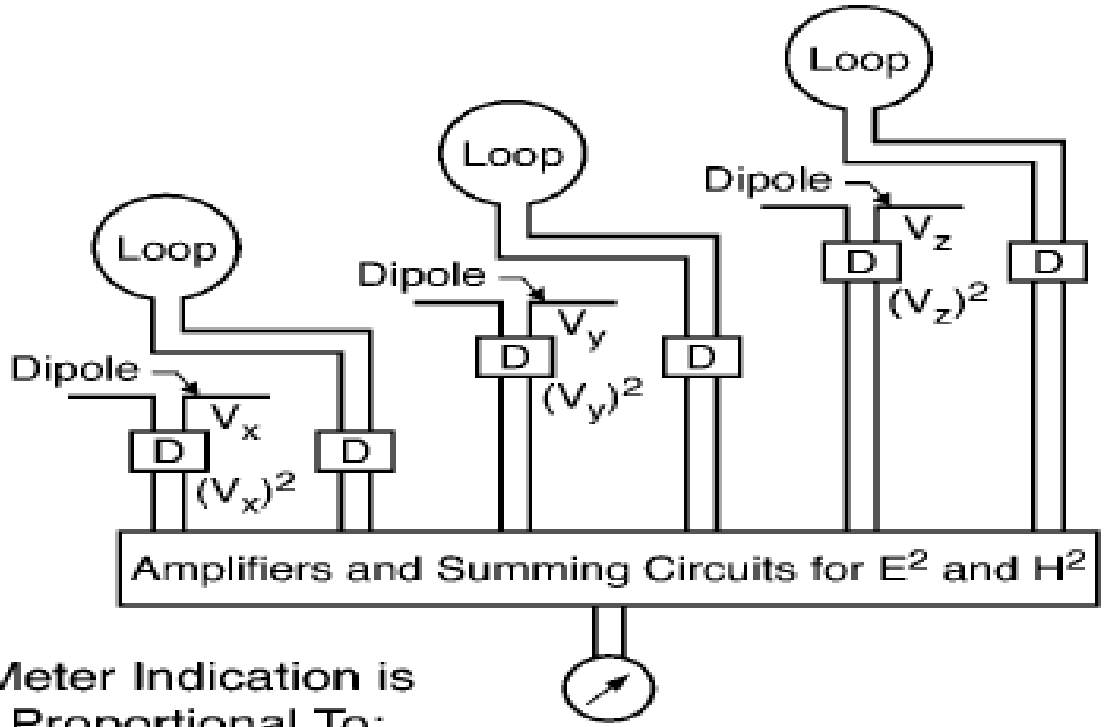
They provide with indications about the effective value (RMS) of the single contributions in frequency (channels) to the total field in the measure point.

☹ They are complicated and expensive;

☺ There are indications about single contrbutions in frequency;

☺ It's possible to extrapolate protective values of field (the highest achievable values.

Broadband Meters

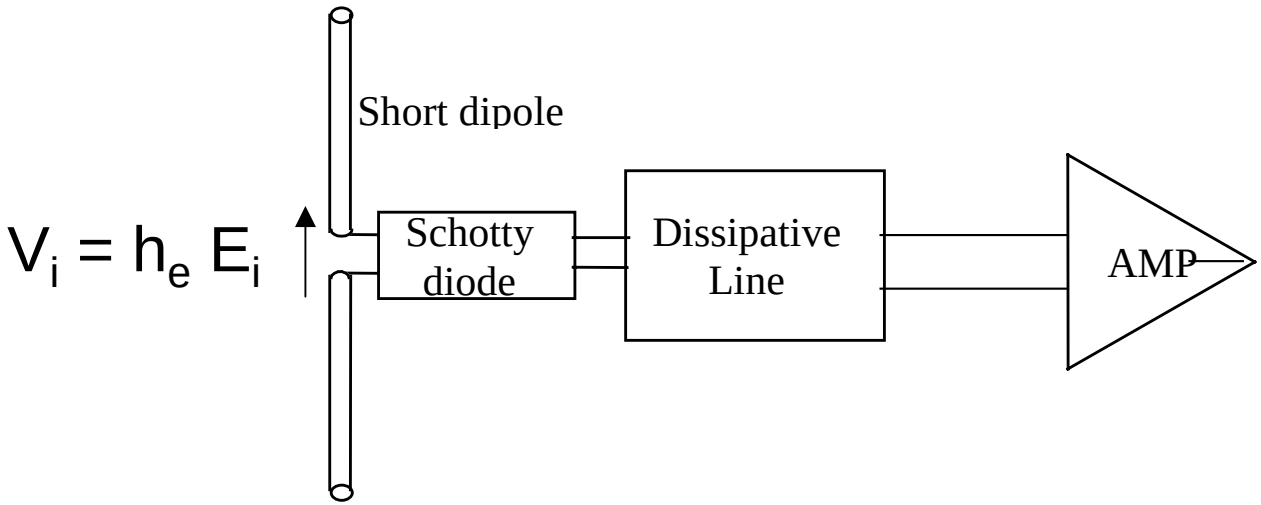


Meter Indication is Proportional To:

$k_e^2 |E|^2; k_h^2 |H|^2$

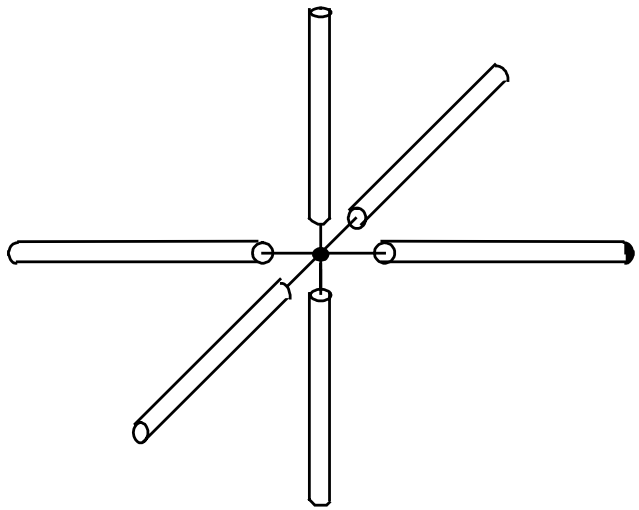
Note:
D – Square Law Detector

Electric field Probe (single dipole version)



The dipole measures the component of electric field parallel to the dipole

Triaxial Electric Field Probe (isotropous)

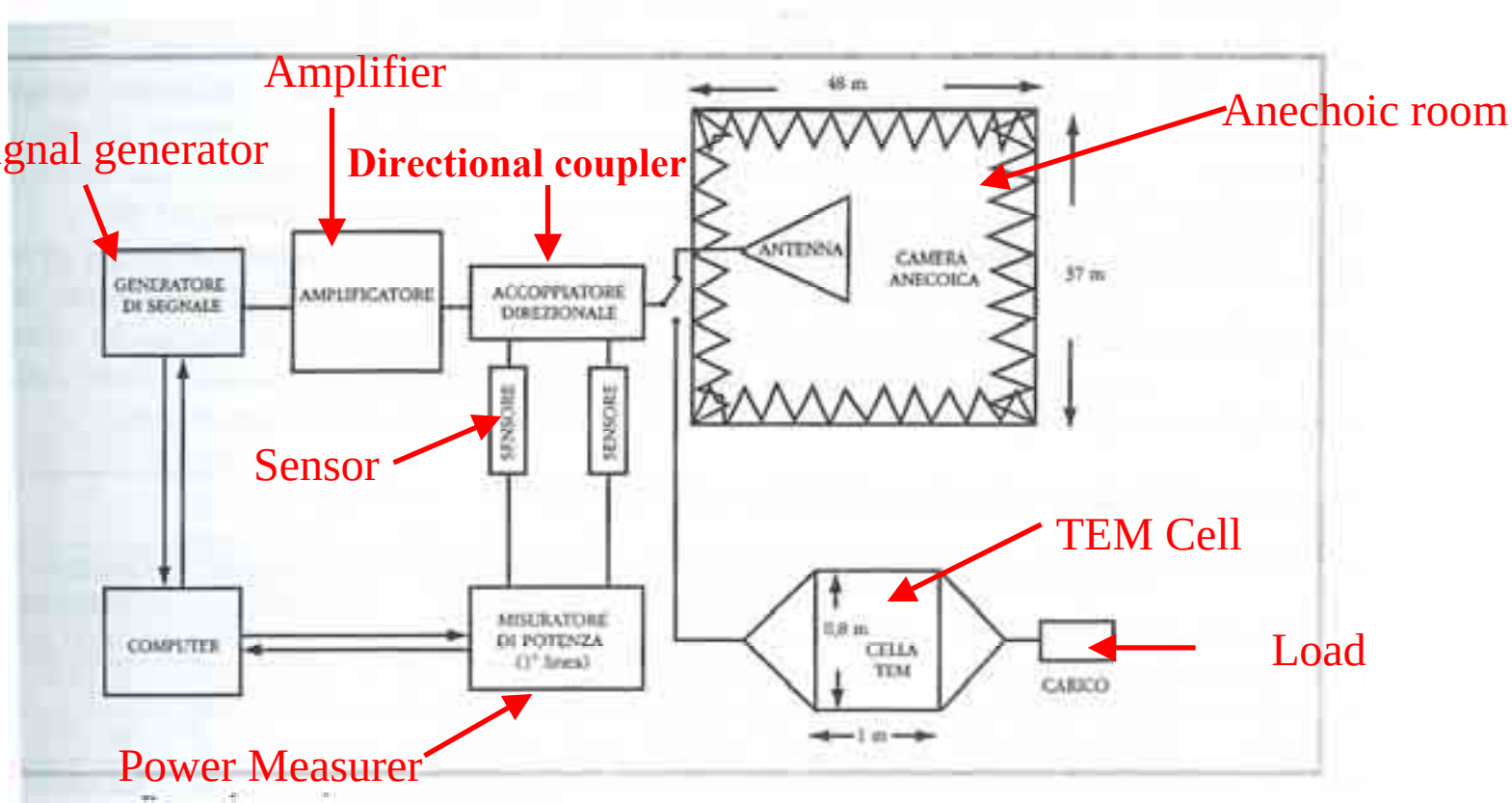


The three measured tensions are sent to an adder and the result is:

$$V_0 = V_{0x} + V_{0y} + V_{0z} = kh_e^2(E_x^2 + E_y^2 + E_z^2) = kh_e^2|\mathbf{E}|^2$$

Calibration in high frequency (10 kHz-300 GHz)

The sensors are calibrated putting them in a region of known field



- Scheme of the circuit for the generation of electromagnetic fields -

Calibration in low frequency (0 -10 kHz)

- Calibration of measurers of magnetic field

  One of calibration methods is putting the probe of field measurer

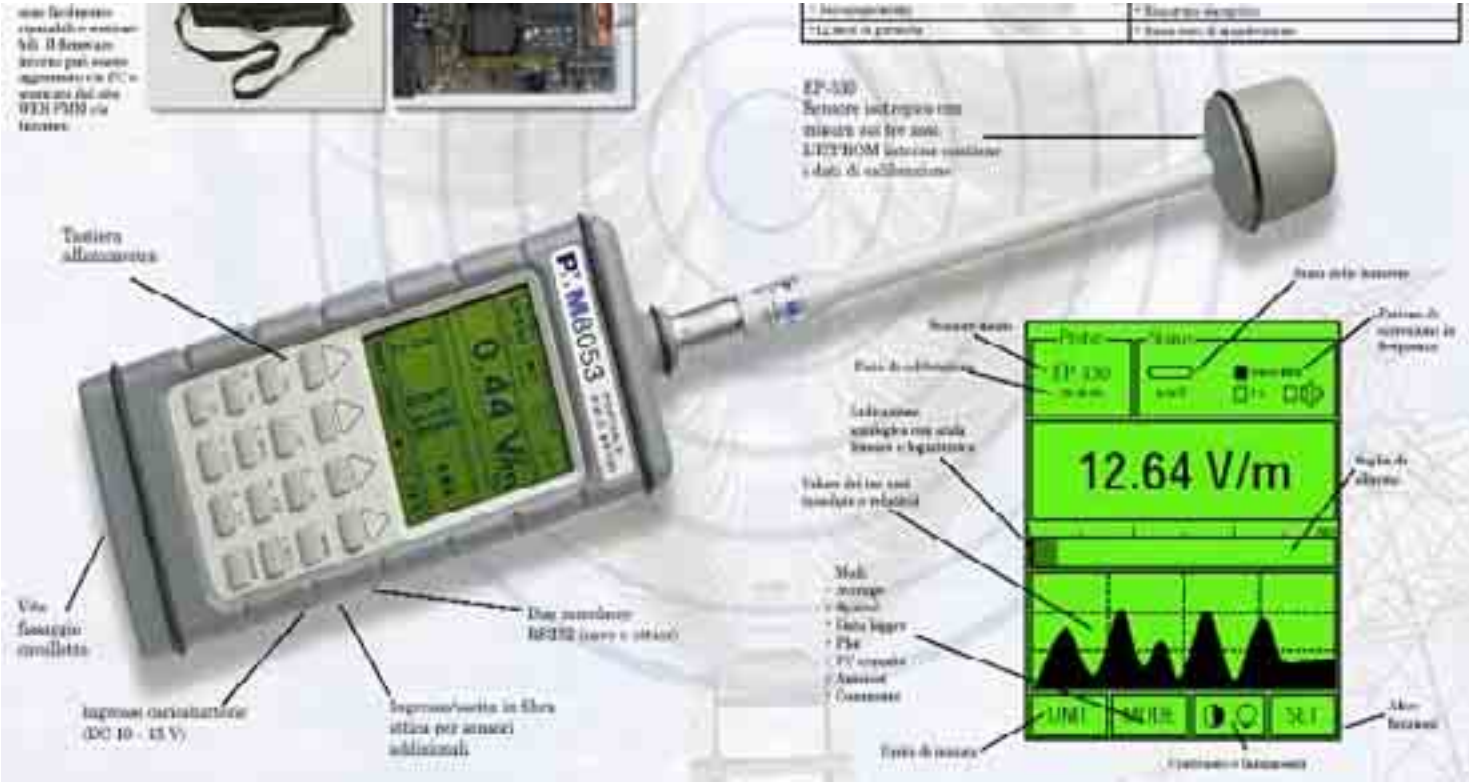
  in a note magnetic field

- Calibration of measurers of electric field

  During the calibration, the probe would be placed in a uniform field produced by parallel plates depending on type of measurer

Measurer Wandel & Goltermann EMR300

Measurer PMM 8053



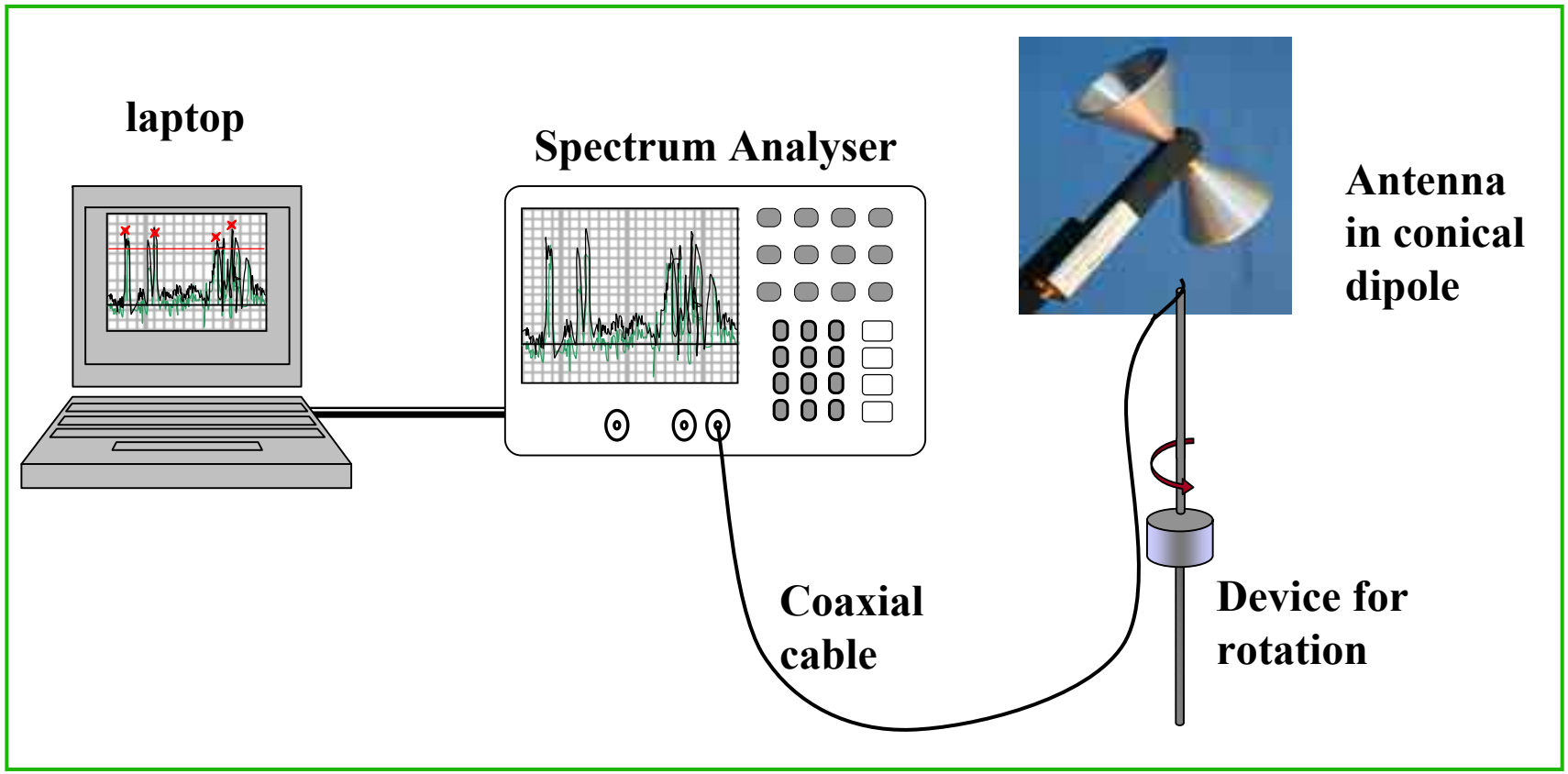
Measurer PMM 8055 (monitoring system)

Solar cells for alimentation

Transmitters for remote wireless connection

Sensor

Instrumentation for measurements on narrow band



Antennas (convertion $E_i \rightarrow V$)

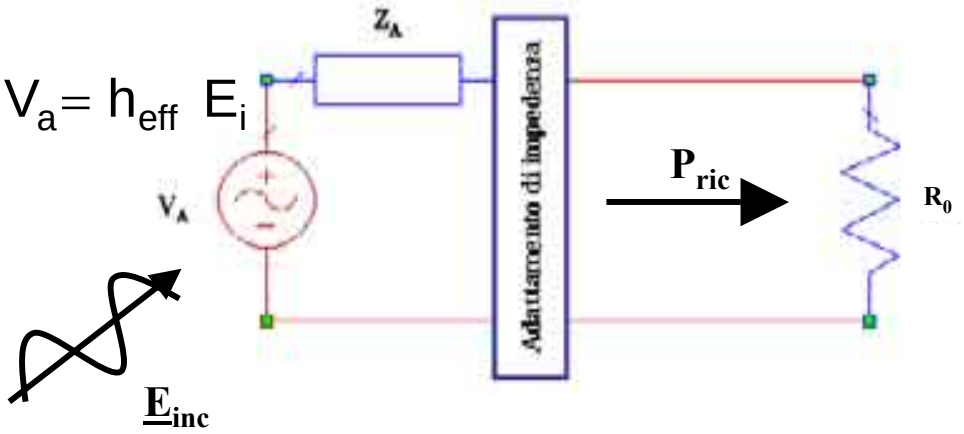
Conical dipole (80 MHz – 2500 MHz)

Log periodic (80 MHz – 2000 MHz)

Spectrum Analyzer Will'tek 5101

How can we go back to E_i from P_{ric}?

$V_a = h_{eff}\ E_i$



$$P_{ric} = \frac{h_{eff}^2\ R_0}{4\,R_A}\ \frac{1}{R_0}\ E_I^2\ e^{-2\alpha l}$$

$$10\log_{10} P_{ric} = 10\log_{10}\frac{h_{eff}^2\ R_0}{4\,R_A} - 10\log_{10} R_0 + 20\log_{10} E_I - 20\log_{10} e^{\alpha l} \quad \Rightarrow$$

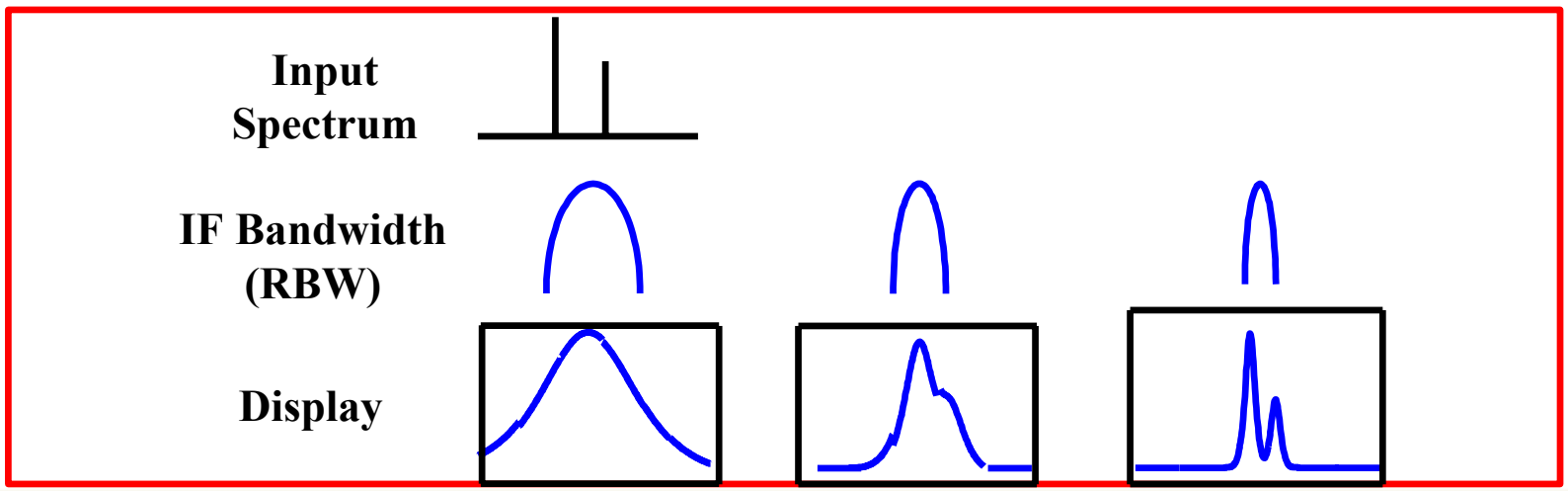
$$\Rightarrow \quad E_I\big|_{dBV/m} = P_{ric}\big|_{dBm} + AF\big|_{dB1/m} + A_c\big|_{dB} - 13$$

How can the parameters of spectrum analyzer be formulated to effect a correct measure of field in narrow band?

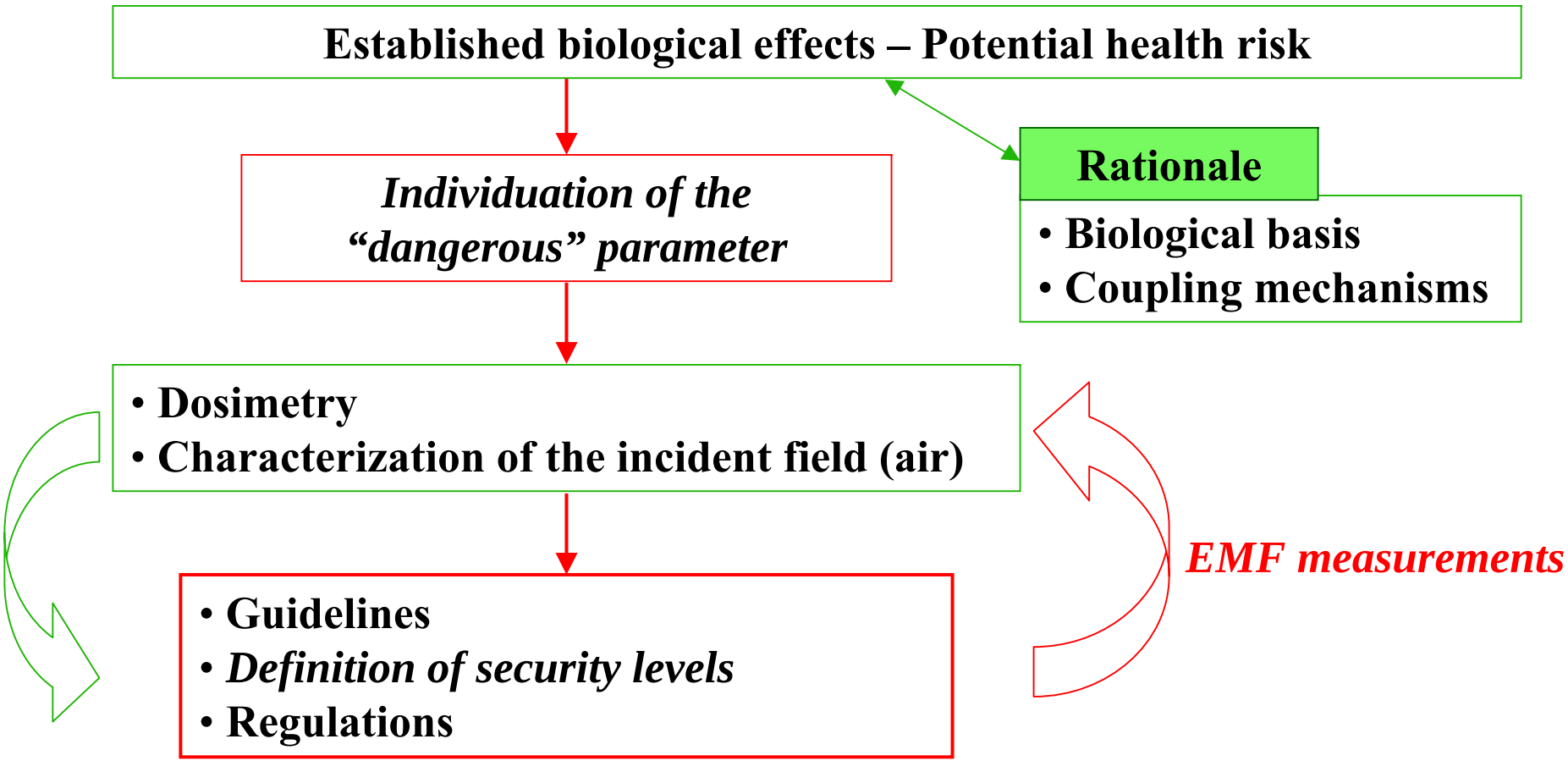
- **Plan SPAN (instant observation band)**
- **Select RBW (Resolution Bandwidth) and VBW (video bandwidth)**
- **Sensitivity (indicate the smallest amplitude noticeable by the analyzer)**

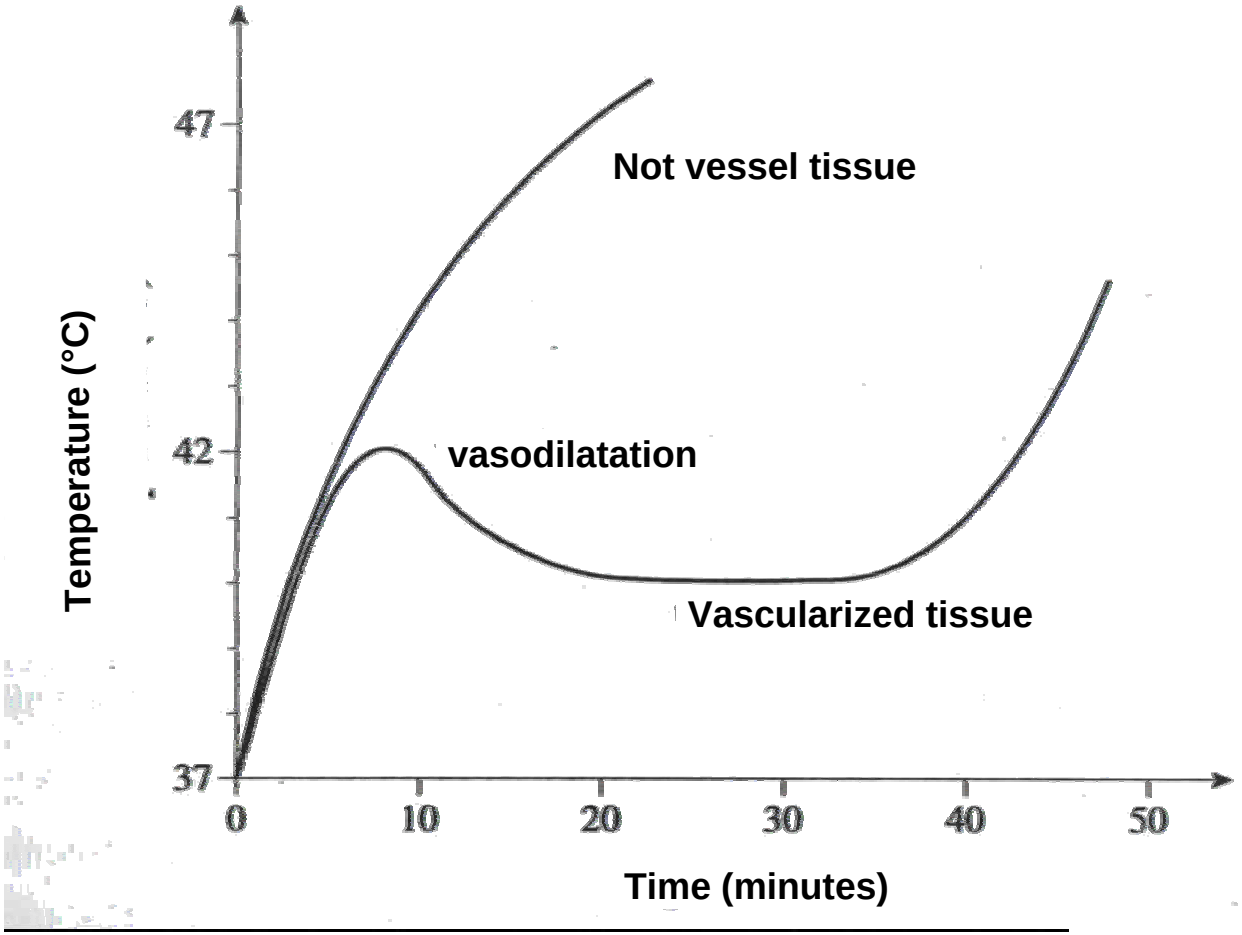
It needs to know the spectral characteristics and the variability in amplitude of the signal to measure

The correct formulations and modalities of measurament depends on the type of the system (radio FM, TV, GSM, etc.) that irradiates field to measure!!!!



Procedure for Standards Definition




Temperature (°C)
47
42
37
0
10
20
30
40
50
Time (minutes)
Not vessel tissue
vasodilatation
Vascularized tissue

Europe Reccommendation 1999

•Recommendation 1999/512/CE of 12th July 1999 ("Recommendation of the council about the limitation of population's exposure to the electromagnetic fields from 0 to 300 GHz")

- It's a Recommendation: the States members are held to follow it, less than they don't define of the more restrictive limits ;
- The limit values of field and of SAR are exactly those of ICNIRP ' 98 reported to the population;
- The Commission comes then invited to elaborate every 5 years one relation on the progresses of the activity of search, integrated also with the experiences of the States members.

Basic restrictions of the electric , magnetic and electromagnetic fields (0 Hz - 300 GHz) - (Europe Reccomandation 12/07/1999)

Frequency	Magnetic Flow Density (μT)	Current Density (mA/m^2) (rms)	Whole body average SAR (W/Kg)	Local SAR (W/Kg) (head and trunk)	Local SAR (W/Kg) (limbs)	Power density S (W/m^2)
0 Hz	40	-	-	-	-	-
> 0-1 Hz	-	8	-	-	-	-
1 - 4 Hz	-	8/f	-	-	-	-
4 - 1000 Hz	-	2		-	-	-
1000 Hz - 100 kHz	-	f/500	-	-	-	-
100 kHz - 10 MHz	-	f/500	0.08	2	4	-
10 MHz - 10 GHz	-	-	0.08	2	4	-
10 - 300 GHz	-	-	-	-	-	10

Reference levels of the electric , magnetic and electromagnetic fields (0 Hz - 300 GHz; not disturbed effective values (RMS)) - (Europe Reccomandation 12/07/1999)

Frequency	E (V/m)	H (A/m)	B (μT)	Seq (W/m²)
0 - 1 Hz	-	$3.2x10^4$	$4x10^4$	-
1 - 8 Hz	10000	$3.2x10^4/f^2$	$4x10^4/f^2$	-
8 - 25 Hz	10000	4000/f	5000/f	-
0.025 - 0.8 kHz	250/f	4/f	5/f	-
0.8 - 3 kHz	250/f	5	6.25	-
3 - 150 kHz	87	5	6.25	-
0.15 - 1 MHz	87	0.73/f	0.92/f	-
1 - 10 MHz	$87/f^{1/2}$	0.73/f	0.92/f	-
10 - 400 MHz	28	0.073	0.092	2
400 – 2000 MHz	$1.375f^{1/2}$	$0.037\ f^{1/2}$	$0.0046f^{1/2}$	f/200
2 – 300 GHz	61	0.16	0.20	10

Italian Regulations

• DM 381/98 “Regulation bringing norms for the determination of the roofs of radio frequency compatible with the human health "

- It was the firt national regulamentetion with the applicative guidelines G.U. n. 257 of 3/11/98
- It applies to
  - – fixed system of radio and TV telecomunication (no mobyle phones, no RADAR);
  - – population (no medical applications)
  - – the frequency range 100 kHz - 300 GHz.
- It fixes
  - Exposure limits
  - ***Caution values that must be respected in structures where people remain for more then 4 hours***

•**General policy law n. 36 of 22th february 2001 :**" General policy law for the protection from the exposures to electric, magnetic and electromagnetic fields" :

- •It applies to
  - • frequencies between 100 kHz and 300 GHz;
  - •Not exposures for medical reasons;
  - •Long distance power lines, diffusion radio equipment and radar;
- •It defines a land register for equipments;
- •It fixes:
  - •Exposure limits;
  - •Attention values;
  - •***Quality targets (for a progressive reduction of the exposure to electric, magnetic and electromagnetic fields) that must be respected in structures where people remain for more then 4 hours.***

• Implementation Decrees of the general policy law:

DPCM dell' 8 luglio 2003 "Fixation of the exposure limits, the attention values and the quality targets for the protection of the population from the exposures to electric, magnetic and electromagnetic fields generated by frequencies between 100 kHz and 300 GHz "

DPCM dell' 8 luglio 2003 : "Fixation of the exposure limits, the attention values and the quality targets for the protection of the population from the exposures to electric, magnetic and electromagnetic fields generated by low distance power lines (frequency= 50 Hz)".

DM 381/98

f	Exposure limits			Caution values		
	E_{rms} (V/m)	H_{rms} (A/m)	S_{eq} (W/m²)	E_{rms} (V/m)	H_{rms} (A/m)	S_{eq} (W/m²)
0.1 - 3	60	0.2	-	6	0.016	
>3 - 3000	20	0.05	1	6	0.016	0.1
>3000 - 300000	40	0.1	4	6	0.016	0.1

DPCM 8/07/03

(high frequency)

f	Exposure limits			Caution values Quality Targets		
	E_{rms} (V/m)	H_{rms} (A/m)	S_{eq} (W/m²)	E_{rms} (V/m)	H_{rms} (A/m)	S_{eq} (W/m²)
0.1 - 3	60	0.2	-	6	0.016	
>3 - 3000	20	0.05	1	6	0.016	0.1
>3000 - 300000	40	0.01	4	6	0.016	0.1

DPCM 8/07/03

(f=50 Hz)

	E (kV/m)	B (μT)
Exposure limit *(RMS)*	5	100
Attention Value (*Median of values in the space of 24 hours in exercise normal conditions*)	-	10
Quality Target (*Median of values in the space of 24 hours in exercise normal conditions)*	-	3

Technical Regulations

•REGULATION CEI 211-6 :" Guide for the measurement and the evaluation of electric and magnetic fields in the frequency range 0Hz-10 kHz, with reference to the human exposure"
•REGULATION CEI 211-7 :" Guide for the measure and the valuation of the magnetic and electric fields in the range of frequency 100 kHz- 300 GHz with reference to the human exposure"