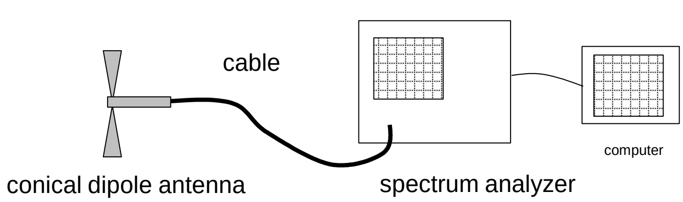
Narrowband Field Measurements

Measurement System

- The measurement system for narrow-band measurements appears as shown in the Figure

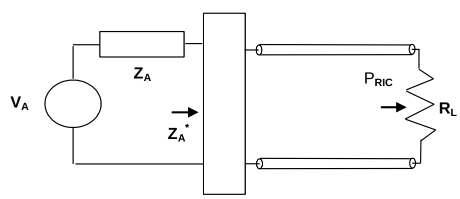


- The system consists of a broadband conical dipole antenna (eg 80 MHz - 2.5 GHz), a connection cable and a spectrum analyzer connected to a computer.

System Model

- For each measurement, the dBm value measured by the spectrum analyzer must be converted into dBV / m.

- To find this link, consider the scheme in the figure below. The matching network transforms the Z_A radiation impedance of the dipole into 50Ω and the long transmission line "l" transfers the signal to the spectrum analyzer whose input impedance is equal to R_L = 50Ω.



Matching network

- With reference to the figure diagram, being $V_A = h_{eff} E_i$ we have:

$$P_{RIC} = \frac{V_A^2}{4R_A} e^{-2\alpha l} = \frac{h_{eff}^2 E_i^2}{4R_A} \frac{R_0}{R_0} e^{-2\alpha l}$$

- defining:

$$AF = 10 \log_{10} \frac{4R_A}{h_{eff}^2 R_0}$$

- We have:

$$10 \log_{10} P_{RIC} = 10 \log_{10} \frac{h_{eff}^2 R_0}{4R_A} - 10 \log_{10} R_0 + 20 \log_{10} E_i - 20 \log_{10} e^{\alpha l}$$

$$P_{RIC}(dB_m) - 30(dB) = -AF(dB_{m^{-1}}) - 17 + E_i\,(dB_{V/m}) - A_C(dB)$$

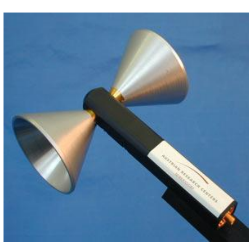
$$P_{RIC}(dB_m) - 30(dB) = -AF(dB_{m^{-1}}) - 17 + E_i\,(dB_{V/m}) - A_C(dB)$$

- From which it results:

$$E_i\,(dB_{V/m}) = P_{RIC}(dB_m) + AF(dB_{m^{-1}}) + A_C(dB) - 13$$

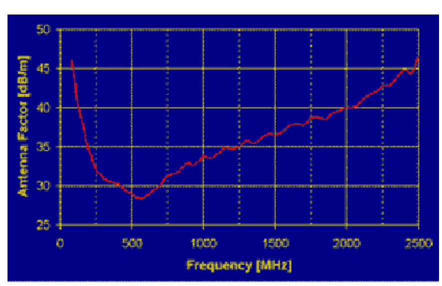
- Where the values of the cable attenuation and the AF antenna factor are provided by the manufacturers.
- Finally, note that for each measurement point three spectra must be acquired corresponding to three mutually orthogonal positions of the conical dipole and the total field is obtained by summing the respective fields in volts / meter.

Antennas



Conical dipole (80 MHz – 2500 MHz)

Antenna factor



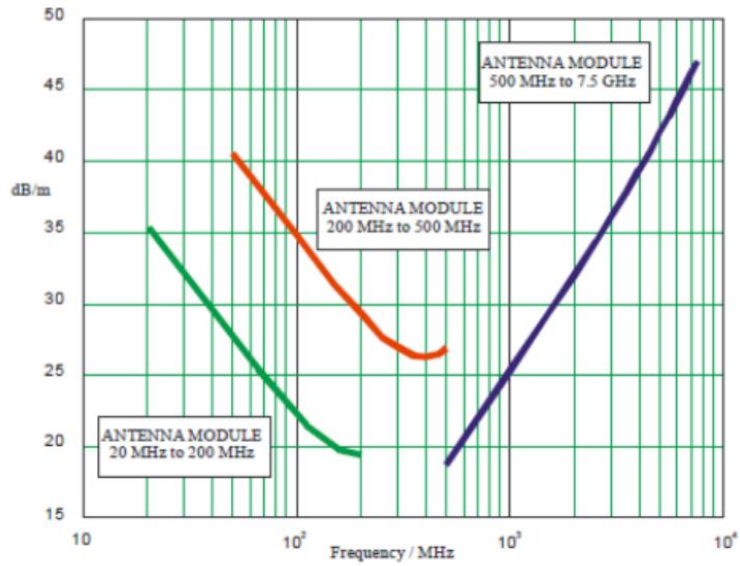


Fig. 4-3: Antenna factor, "Passive" mode.

Evaluation of Measurement Uncertainty

- With reference to the evaluation of the uncertainty of this measurement, since the AF is generally measured for certain frequencies the values at frequencies other than those measured must be obtained by interpolation and this leads to an error which is taken into account with the AF Interpolated.
- In addition, there will be reflections at the analyzer input port which is taken into account by the mismatching
- Typical values for the parameters of interest are:

• AF: antenna factor	normal	$\pm$1.0dB
• AC: cable attenuation	normal	$\pm$0.5dB
• AF interpolated:	rectangular	$\pm$0.25dB
• M: mismatching	U shape	$\pm$0.5dB

Extended Uncertainty

then

- AF: antenna factor 12.2%
- AC: cable attenuation 5.92%
- AF interpolated: 2.92%
- M: mismatching 5.92%

- Being a single direct measurement, the standard uncertainty will be :

$$u(E_i)=\sqrt{\left(\frac{12.2}{2}\right)^2+\left(\frac{5.92}{2}\right)^2+\left(\frac{2.92}{\sqrt{3}}\right)^2+\left(\frac{5.92}{\sqrt{2}}\right)^2}=8.15\%$$

- If we consider a coverage factor k = 2 we obtain an extended uncertainty given by:

u = 2u(E_i) = 16.3%

Total Field Uncertainty

$$E = \sqrt{E_x^2 + E_y^2 + E_z^2}$$

$$u_a^2 = \left(\frac{\partial E}{\partial E_x}\right)^2 u_{xa}^2 + \left(\frac{\partial E}{\partial E_y}\right)^2 u_{ya}^2 + \left(\frac{\partial E}{\partial E_z}\right)^2 u_{za}^2$$

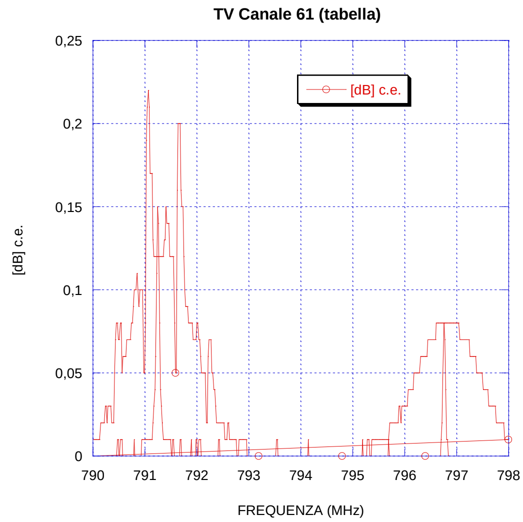
$$u_a^2 = \left(\frac{E_x}{E}\right)^2 u_{xa}^2 + \left(\frac{E_y}{E}\right)^2 u_{ya}^2 + \left(\frac{E_z}{E}\right)^2 u_{za}^2$$

$$u_a^2 = \frac{(E_x)^4}{(E)^2} u_{xr}^2 + \frac{(E_y)^4}{(E)^2} u_{yr}^2 + \frac{(E_z)^4}{(E)^2} u_{zr}^2$$

If we consider a coverage factor k = 2 we obtain an extended uncertainty given by:

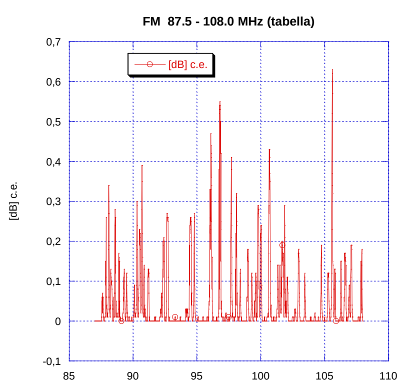
u_E = $2\,u_a^2$

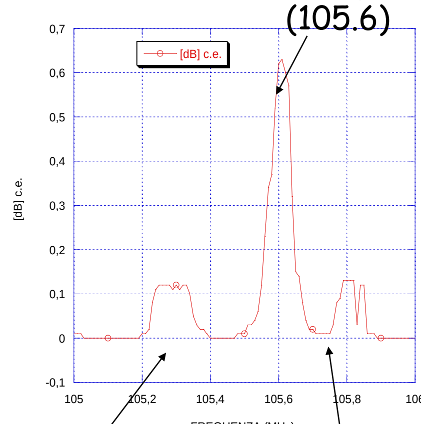
TV signal (measurement)



(Telestudio)

Radio (measurement)





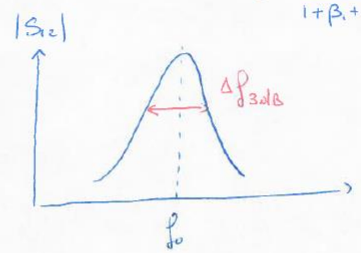
Rete Sport (105.6)

Dimensione suono 2 (105.3)

Radio incontro (105.8)

Q_L of a Cavity by Transmission Measurements

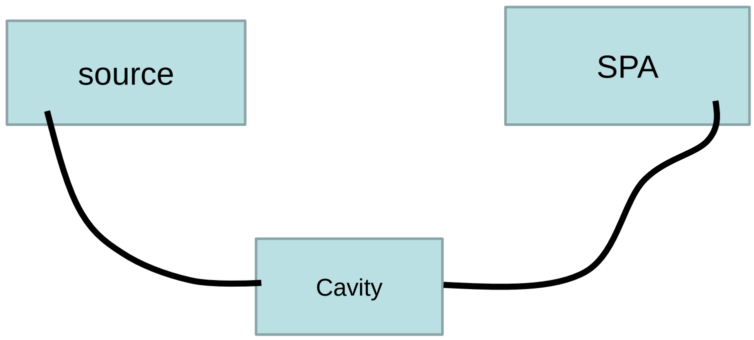
$$S_{12} = \dots = \frac{\dfrac{2\sqrt{\beta_1\beta_2}}{1+\beta_1+\beta_2}}{1 + j\,\dfrac{Q_0}{1+\beta_1+\beta_2}\,\delta} = \frac{S_{12}(f_0)}{1 + j\,Q_L\,\delta}$$



$$Q_L = \frac{f_0}{\Delta f_{3dB}}$$

AUTOMATIC Q MEASUREMENT

Experimental Set-up



It is possible to use the “source sweep” mode and the “trace on” mode of the SPA to get the frequency response of the cavity from which to evaluate the Q_L