



## PRACTICE 08 – MEASUREMENTS ON COMPLEX SIGNALS

### 1. Spectrum measurement with uncertainty

1.1 Use the synthesizer (R&S SML03) to generate a sinusoidal wave. Select the frequency of **96 MHz and Amplitude 5 dBm**. Use the connectors to measure the signal with the SPA. Visualize and save the amplitude and the frequency of the signal, reporting the **uncertainty of the amplitude measurement** (both in dBm and mW) and the **uncertainty of the frequency measurement** (to be minimised). **(REPORT)**

In order to estimate the uncertainty of the frequency measurement, the SPA Company suggest to use the following relationship:

Max. deviation =  $\pm$  (frequency  $\times$  Ref. freq. + 0.5%  $\times$  span + 10%  $\times$  RBW +  $\frac{1}{2}$  last digit) where Ref. freq. =  $10^{-6}$ .

In order to estimate the uncertainty of the amplitude, the SPA company suggest a maximum uncertainty of 0.5 dB (for levels from 10 and -70 dBm, RBW < 100 kHz, S/N > 16 dB)

1.2 With the help of markers, measure the amplitude and the frequency of the second and third harmonic of the signal. **(REPORT)**

### 2. Step recovery diode and multiplication in frequency

2.1 Apply the signal at point 1 to the input of the amplifier (Mini Circuit ZHL 1A) supplied with **15 V (supply the amplifier starting from 0 V and grow slowly- check that the current consumption is lower than 350 mA)**. With the help of markers, measure the amplitude and the frequency of the fundamental harmonic and of the second and third ones. What do you notice? **(REPORT)**

2.2 **Put RF OFF**. Add a filter (BIF 70 Mini Circuit) to the output of the amplifier. Put **RF ON** and measure the spectrum. What happens? **(REPORT)**



2.3 Put RF OFF. Add the SRD in cascade (**GC 100 Herotek**) (input side “herotek” label). Put **RF ON** and measure the spectrum (STOP 3 GHz). What happens? **(REPORT)**

2.4 With the help of markers, evaluate the amplitude and the frequency of the first five harmonics. **(REPORT)**

2.5 Put **RF OFF** and insert the filter (K&L MW). Put **RF ON** and visualize the signal on the spectrum analyser. Which harmonic has been selected by the filter? Insert markers and save. **(REPORT)**

### 3. Spectrum of a frequency modulated signal

3.1 Visualize the spectrum of frequency modulated signal with the following settings:

**Carrier frequency** = 1 GHz

**FM deviation** = 1 kHz

**FM source** = LF Gen

**Ext. Coupling** = AC

**LF Gen. Freq.** = 3 kHz

**FM bandwidth** standard

Modulation index  $m = \text{FM deviation} / \text{LF Gen. Freq}$  **(REPORT)**

3.2 Observe how, by increasing the modulation index ( $m$ ), more spectral lines will appear and how the band expands. In the report, plot two graphs of two cases of your choice by specifying the settings both of signal generator and of SPA. Evaluate the Carson band. **(REPORT)**

3.3 Choose 10 values of the modulation index  $0 < m < 6$  and measure the amplitude of the carrier. Plot these amplitudes and overlap them with the theoretical expectations (MATLAB command for the Bessel functions  $J_n(x)$ : `besselj(n,x)`). **Be careful: you are using dB scale.** **(REPORT)**



3.4 Report a measurement of the FM modulated signal in which the carrier is deleted, verifying the theoretical expectations (in the range  $0 < m < 6$  there are two of them). **(REPORT)**

#### **4. Spectrum of a frequency modulated signal overlapped to an amplitude modulated signal**

4.1 Leaving on the FM modulation with an assigned modulation index, turn on the AM modulation with the same **LF GenFreq** and a fixed modulation index. Observe how the spectrum is not symmetrical. **(REPORT)**

4.2 Measure the position and the intensity of the first side band (right and left). Save the spectrum and report it. **(REPORT)**

#### **5. Frequency response of a filter**

Measure the frequency response of the filter NBP 70+ by using the sweep mode of the signal generator between 1 and 200 MHz, step = 0.1 MHz (use trace max hold on the SPA). With the help of markers, evaluate the bandwidth of the filter. **(REPORT)**



## 6. EM field measurements

7.1 Connect the antenna (Passive mode) to the spectrum analyser (Full Span) by using a coaxial cable. Set **Trace -> max hold**. Which signals are measured (TV, radio, Wi-Fi)? Save the trace. **(REPORT)**

7.2 Set the max hold mode and the band between 80 MHz and 110 MHz, save the trace. On the saved trace, evaluate (with MATLAB) the three radios with higher power (use the function `[frequency, amplitude]= ginput(3)`). **(REPORT)**

7.3 Place the marker on the frequency of a radio (with Resolution BW = 100 kHz) and with **function – marker demodulation – FM** you can listen to the sound of the radio.

7.4 Measure the received power (RBW = 300 kHz, Trace Max Hold). Evaluate the electric field in dB(V/M) by using the formula:

$$E_i(\text{dBV/m}) = \text{PRIC (dBm)} + \text{AF (dBm}^{-1}) - 13$$

The antenna factor (as a function of the frequency) is reported in the attached data sheet and it includes also the attenuation of the cable. Evaluate also the magnetic field in A/m in the case of far field. Repeat the measurement in 3 mutually orthogonal positions. Report the measurements with their uncertainty considering that  $\delta A_F = \pm 1.5$  dB (normal distribution),  $\delta A_{\text{Finterpolated}} = \pm 0.25$  dB (rectangular), mismatch =  $\pm 0.5$  dB (U shaped)). Evaluate mod(E) and mod(H) with their uncertainty. **(REPORT)**

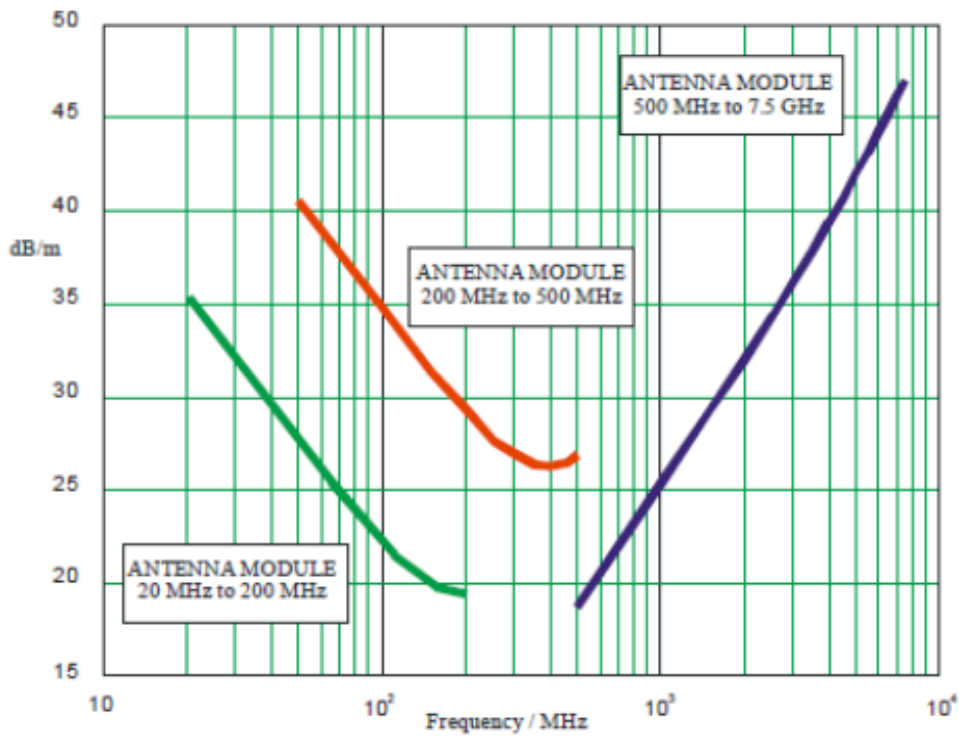


Fig. 4-3: Antenna factor, "Passive" mode.

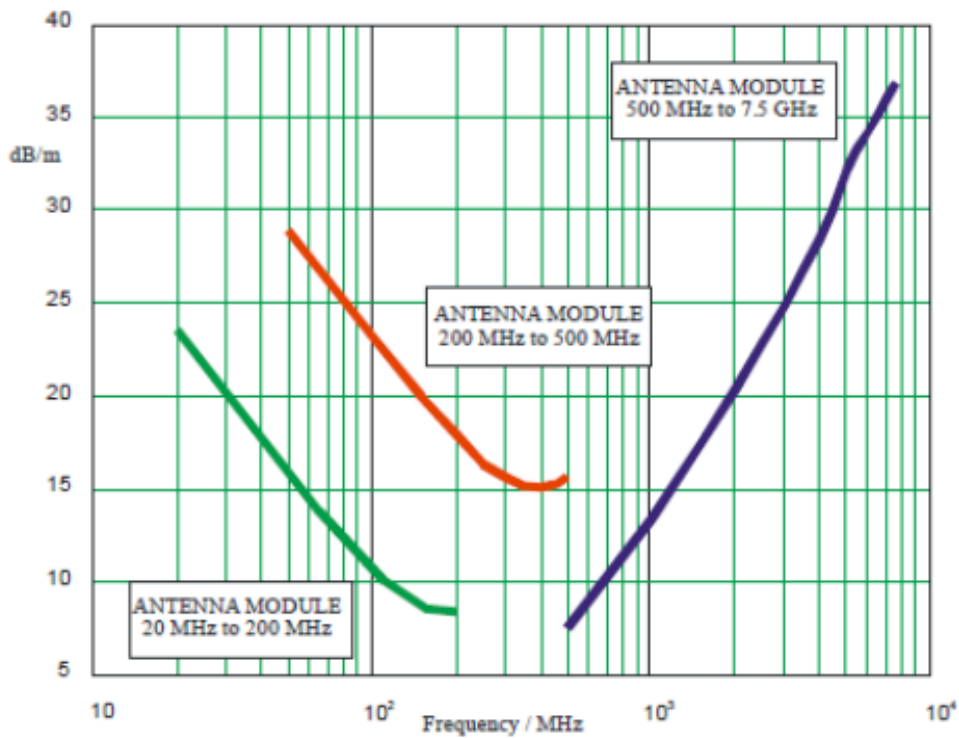


Fig. 4-4: Antenna factor, "Active" mode.