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Instruction for Laboratory classes on Wireless Communications

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Exercise 4. The co-channel interference analysis

The aim of this exercise is to:

- learn what is co-channel interference,
- learn how to analyse the co-channel interference with Radio Mobile software.

1. References:

1. RECOMMENDATION ITU-R BS.412-9 Planning standards for terrestrial FM sound broadcasting at VHF
2. Gordon L. Stüber, "Principles of Mobile Communication", Second Edition, Kluwer Academic Publishers, 2002

2. The scope of the exercise.

In this exercise you will learn what is the co-channel interference and how to simulate this in Radio Mobile software.

Interference is the sum of all signal contributions that are neither noise not the wanted signal. The co-channel interference is caused by frequency reuse in wireless system where several base stations use the same set of frequency. These base stations are called co-channel bases. The interfering signal on the frequency of serving base station creates the potential co-channel interference. Schematically, the co-channel interference in the cell served by the T1 transmitter coming from the T2 station operating on the same frequency is shown in Figure 1. The figure also defines the interference level measure, which is the ratio of the base station signal to the interference (S / I). For each wireless system, the maximum interference level is determined by the S / I parameter.

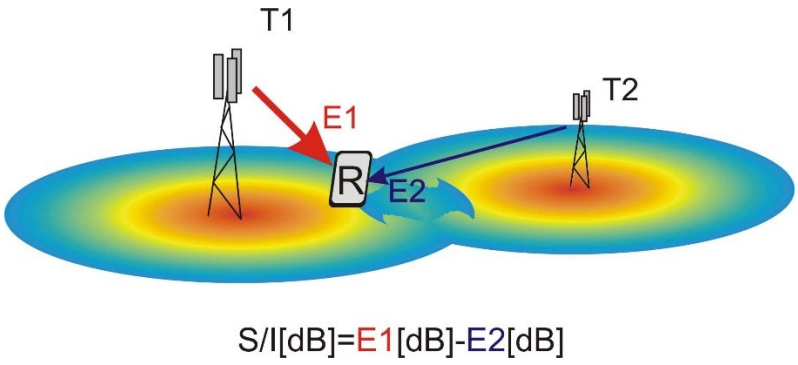


Fig.1. The co-channel interference

In the case of neighbouring base stations, the same frequencies should not be used, because on the border of the coverages of both stations there will be an area with a very high level of interference (as shown in Fig. 2). To avoid this, use different frequencies in adjacent stations, and keep the co-channel stations separate from each other (as shown in Fig. 3).

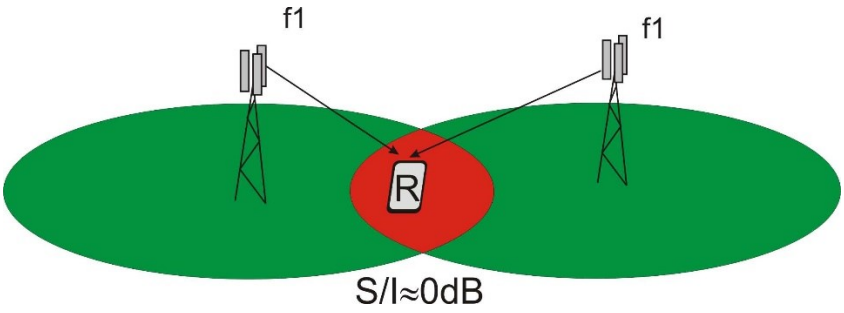


Fig.2. Co-channel interference at the border of the coverages of stations, that are using the same frequencies f1

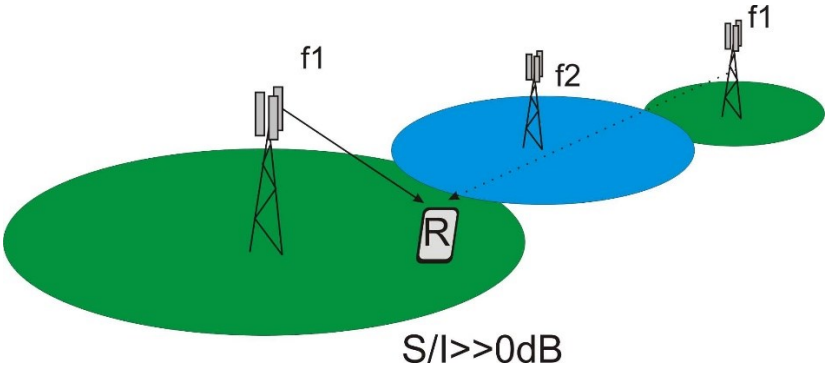


Fig. 3. Co-channel noise reduction through station separation using the same frequencies f1

Co-channel interference cannot be reduced by increasing the power of the transmitter. This is because an increase in carrier transmit power increases the interference to neighbouring co-channel cells. To reduce co-channel interference, co-channel cells must be physically separated by a minimum distance to provide sufficient isolation due to propagation or reduce the footprint of the cell. Some factors other than reuse distance that influence co-channel interference are antenna type, directionality, height, site position etc.

In this exercise we will analyse co-channel interference in FM sound broadcasting at VHF [1]. For different areas on which you will simulate the coverage please apply the values of minimum field strengths given in Table 1[1].

Tab. 1. Minimum field strengths for coverage planning

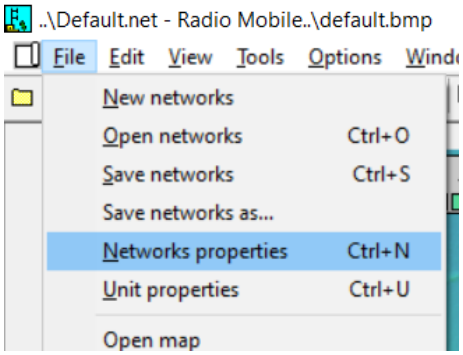
Areas	Services	
	Monophonic dB(μV/m)	Stereophonic dB(μV/m)
Rural	48	54
Urban	60	66
Large cities	70	74

For the FM system, the maximum level of co-channel interference was specified in the ITU-R recommendation [1] using the signal-to-noise ratio ("Radio-frequency protection ratio (dB)"). In the exercise it should be assumed that the maximum S / I value for the FM system in mono mode is 36 dB.

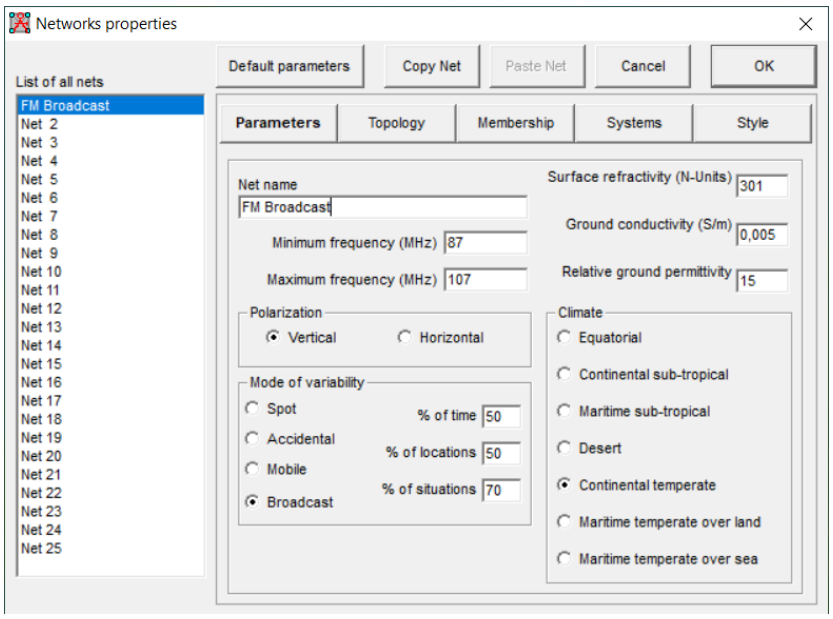
3. The course of the exercise

3.1. Create the project in Radio Mobile program

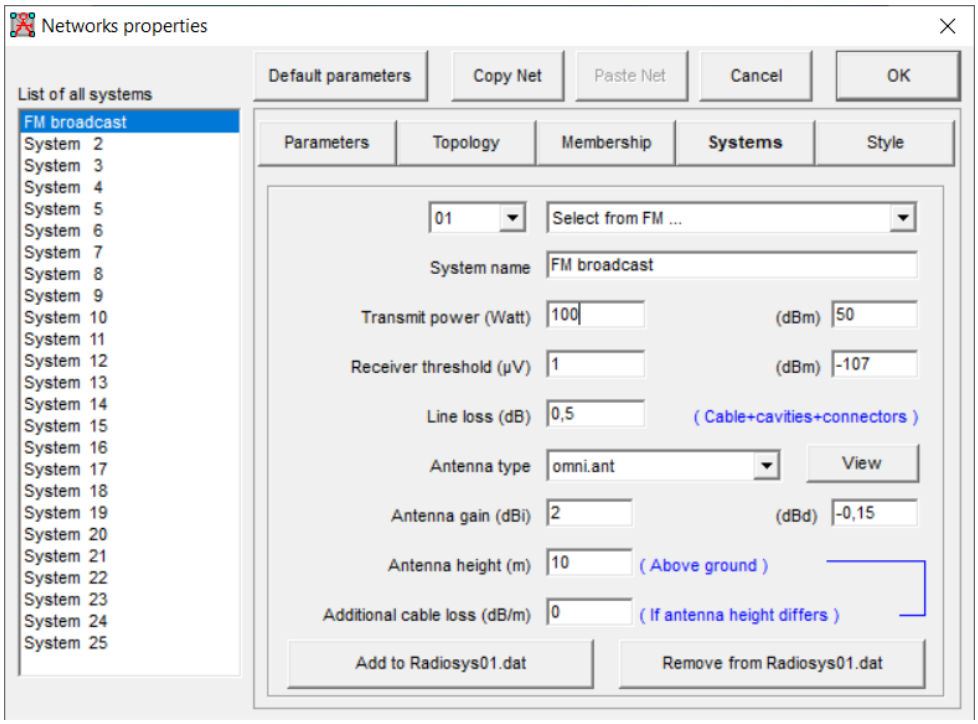
The exercise can be performed using a map of any area, so that the "Height" parameter in the "Map properties" window is 100 km.
Transmission system parameters should be configured in the File> Networks properties menu:



Then in the "Network Properties" window, select the name of the Net 1 network in the left pane and define its parameters, as shown in the window below. We define the network name as (Net name): FM Broadcast, Frequency range 87 - 107 MHz, analysis type (Mode variability) Broadcast.



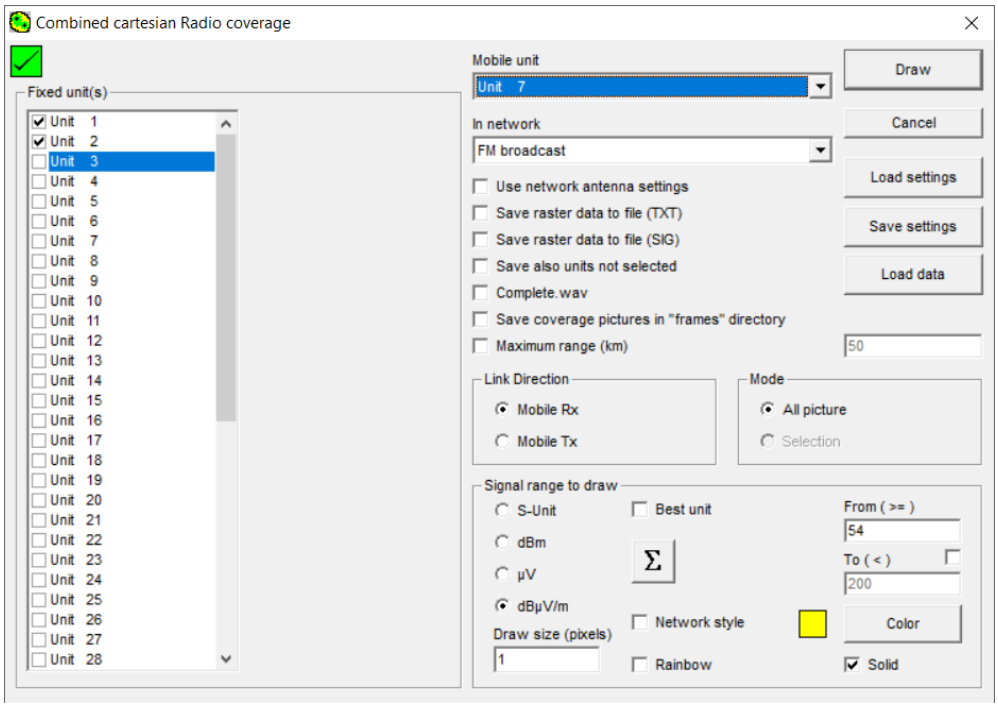
In the "Memebership" tab, select which base stations (not yet placed on the map) belong to the selected system. We mark 10 base stations.
Stations from "Unit 1" to "Unit 9" will act as transmitters with antennas placed 40m above the ground (option> "antenna height"> "Other" 40m). Terminal "Unit 10 will function as a mobile terminal." In its case, select "Antenna height"> System.



3.2. Analysis of the coverage of a system with many base stations

Place the cursor in the selected place on the map, where the base station is to be located. Initially, a flat piece of land without buildings should be selected. Simulate the range of a single base station (menu: Tools> radio coverge> single polar) to estimate its range. The minimum field strength should be set as in exercise 1, at 54 dBµV / m.
Then, 8 additional base stations should be placed so as to cover the largest, consistent area

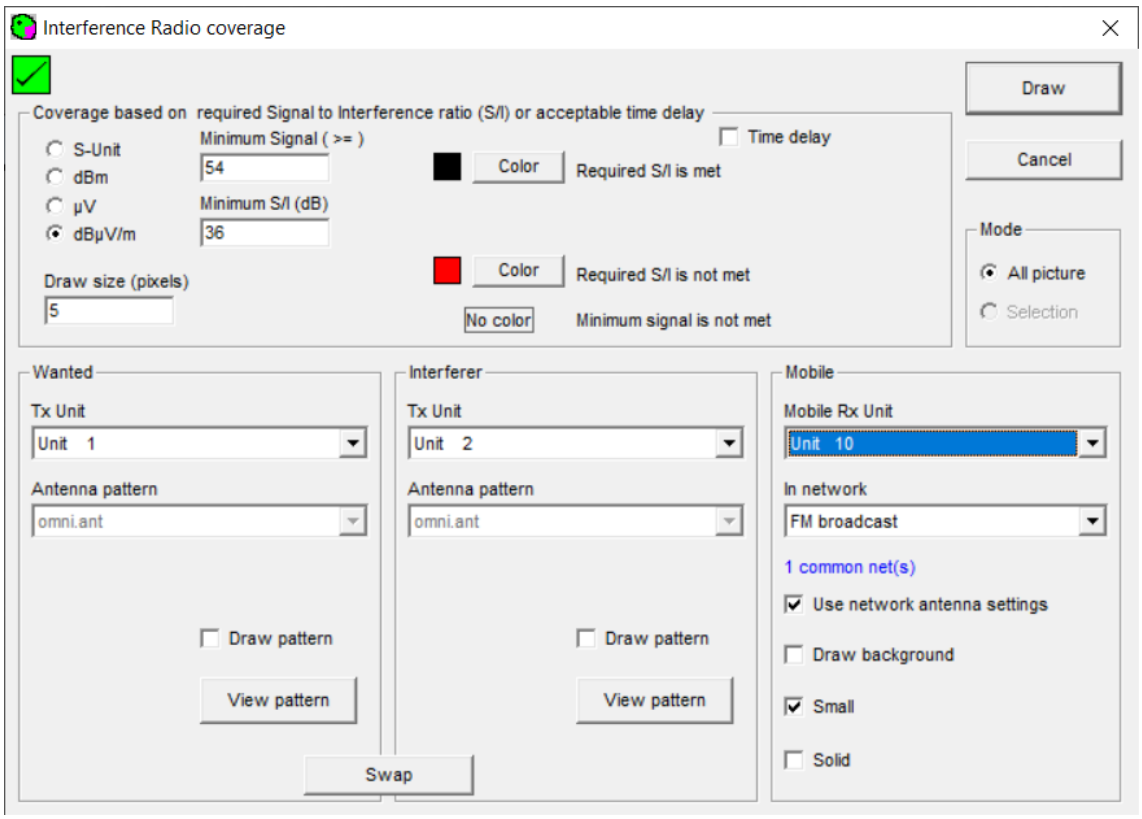
with access to the signal. New stations should be set up so that the selected consistent area is covered with a signal enabling the signal to be received by the mobile receiver (unit 10). The parameters of the 8 added stations should be the same as for the first station.
The total coverage of several base stations can be calculated from the menu: Tools> radio coverage> Combined Cartesian. It is easier to plan the placement of transmitters by making new simulations every time you add another base station. Below is a window view to simulate the total range of stations 1 and 2, after adding station 2 (unit 1 and unit 2 are marked as "Fixed Units").
To speed up the execution of a map with a combined range of many stations when making changes to the design, calculations can be made for a raster spanning several pixels. In this case, we change the "Draw size (pixels)" parameter from 1 to eg 5. However, the final result of network planning should be done on an accurate map (1 pixel).



The combined coverage of all 9 base stations should be simulated. The stations should be configured (select the location, transmitter power, antenna type, etc.) so that the entire area is accessible to the mobile unit. In order to ensure consistent coverage of a selected area, it may be necessary to change the initial position of the base stations. This can be done by placing the cursor in a new location and selecting the "Units properties" menu, for the selected "unit" transmitter, press the "place unit at cursor position" button.

3.3.Analysis of co-channel interference

The co-channel interference between 2 stations can be analysed using the menu Tools> Radio Coverage> Interference. In the "Interference Radio coverage" window, you can configure the parameters for the disturbance analysis. From the "Wanted" list, we select which transmitter serves the analysed area. From the "interferer" list, we choose which transmitter we treat as interfering. Set the mobile terminal to "Unit 10".
The analysis takes into account the minimum level of the signal received from the serving stations, which is set with the "Minimum signal" parameter, in our case 54 dBµV / m. The "Minimum S / I" parameter defines the minimum acceptable level of separation between the operating signal and the disturbance. We set this parameter at 36 dB.



As a result of the analysis, the areas where the interference level is acceptable will be shown in black, and the areas in which the interference is too high despite the sufficient signal level from the serving station, will be shown in red.
The condition for the proper functioning of a system using many base stations is to ensure at least the minimum field strength in the entire area and the absence of co-channel interference (no "red" areas for each station).

3.4. Analysis of the system with 9 base stations

As part of the exercise, a system consisting of 9 transmitters should be designed, with consistent coverage (without areas where the service is not available) on selected area of the site. For this system, suggest which stations can use the same frequency.

When preparing the report, the coverage of 9 base stations should be shown. Then you should analyse the interferences between them:

a. The level of co-channel interference between neighbouring stations should be investigated, assuming that they operate on the same frequency (which is unacceptable case in real life). The result will illustrate the situation shown in Figure 2.
b. Then propose which of the 9 base stations could use the same frequencies while maintaining the required level of interference. Show the result of the simulation of the co-channel interference for the proposed method of channel allocation.
c. Repeat the analysis for increased transmitting power to 200 W but with the use of directional antennas.

THE END