RECOMMENDATION ITU-R SM.856-1*

NEW SPECTRALLY EFFICIENT TECHNIQUES AND SYSTEMS

(1992-1997)

Scope

This Recommendation provides additional methods to reduce interference and improve spectrum utilization.

Keywords

Adaptive antenna, re-use distance, co-channel, coverage area

The ITU Radiocommunication Assembly,

considering

a) that the radio spectrum is a limited resource;

b) that there is spectrum congestion in certain frequency bands in populated areas;

c) that when the system design parameters and geographical distribution of stations are both known, improved technical planning can enhance usage of the frequency spectrum;

d) that due to the rapid development of different radio services, sharing conditions in many frequency bands are becoming increasingly difficult;

e) that in many cases it is difficult or impossible to ensure sharing by conventional geographic or frequency separation;

f) that the advance of technology has made possible the introduction of new spectrally efficient techniques and systems;

g) that the use of interference cancellers could enable otherwise interfering links to operate simultaneously;

h) that special screens improve antenna spatial selectivity;

j) that adaptive antenna systems reduce interference on shared frequencies,

recommends

1 that interference cancellers, screens and adaptive antennas (see Annex 1 for an example) should be considered for use as additional methods to reduce interference and improve spectrum utilization by enabling otherwise interfering links to operate simultaneously with a minimum of interference.

NOTE 1 – Future examples will be included with the objective of increasing spectrum utilization.

ANNEX 1

Reduction of base station co-channel re-use distance using adaptive antenna techniques

In conventional frequency planning the re-use distances between co-channel base stations in the land mobile service have to be sufficiently separated so that interference does not occur. Studies found that if adaptive antennas are used, additional co-channel base stations can be inserted in a service area such that the resulting separation of all base stations can be reduced by a factor of about 0.625, with minimal impact on their coverage areas. This reduced frequency re-use distance effectively increases the service capacity of the frequency spectrum, by allowing channels to be used more

* Radiocommunication Study Group 1 made editorial amendments to this Recommendation in the years 2018 and 2019 in accordance with Resolution ITU-R 1.

frequently in a service area, leaving other channels free to cover other service areas. In order to show that using adaptive antennas is a spectrally efficient technology, a study was conducted to demonstrate its effectiveness.

1 Reduced re-use distance scenario

Simplex co-channel base stations are usually separated sufficiently (by about 120 km) so that interference does not occur and each operates as a "stand-alone" system. In this study they are purposely situated closer together, at about two thirds of the normal separation distance or 80 km, so that each is "jamming" the other, effectively reducing their coverage areas. An adaptive array antenna is then deployed at each base station to restore "normal" operation at the reduced separation distance.

2 Characterization of the adaptive antennas

The adaptive antenna used is a simple side lobe canceller with auxiliary (AUX) antennas combined with the conventional (MAIN) antenna via complex adaptive coefficients (weights; see Figs. 1 and 2). Based on inputs from each element of the array of auxiliary antennas and on the sum of the main signal antenna and the sum of the array of auxiliary antennas, an algorithm determines the coefficients which are used to weigh the signal of each element of the array of auxiliary antennas. The adaptive array antenna is only activated when the interferer exceeds a certain signal strength level with respect to the desired signal, say 6 dB. The description of this activation is not in the scope of the present study, but could be based on the successful demodulation of squelch tones, for example.

3 Computing coverage area

In the study typical values of parameters used for the modelling of minimum re-use separation for the VHF band are summarized in Table 1.

FIGURE 1

Sketch of adaptive side lobe canceller proposed for simplex PMR re-use base stations

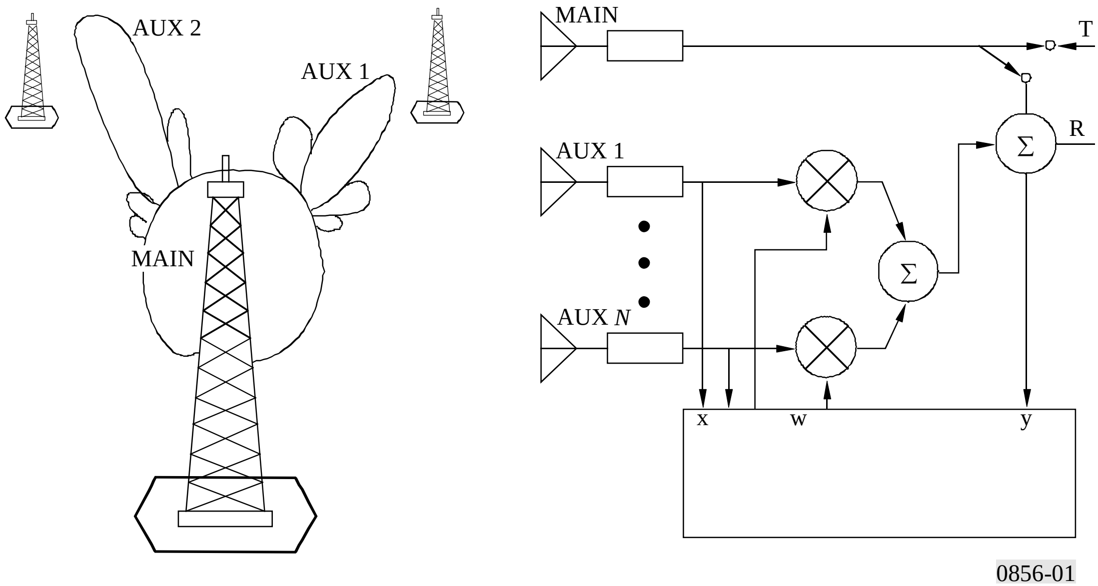

FIGURE 2

Sketch of MAIN and AUX antenna patterns and locations of desired and interfering signals

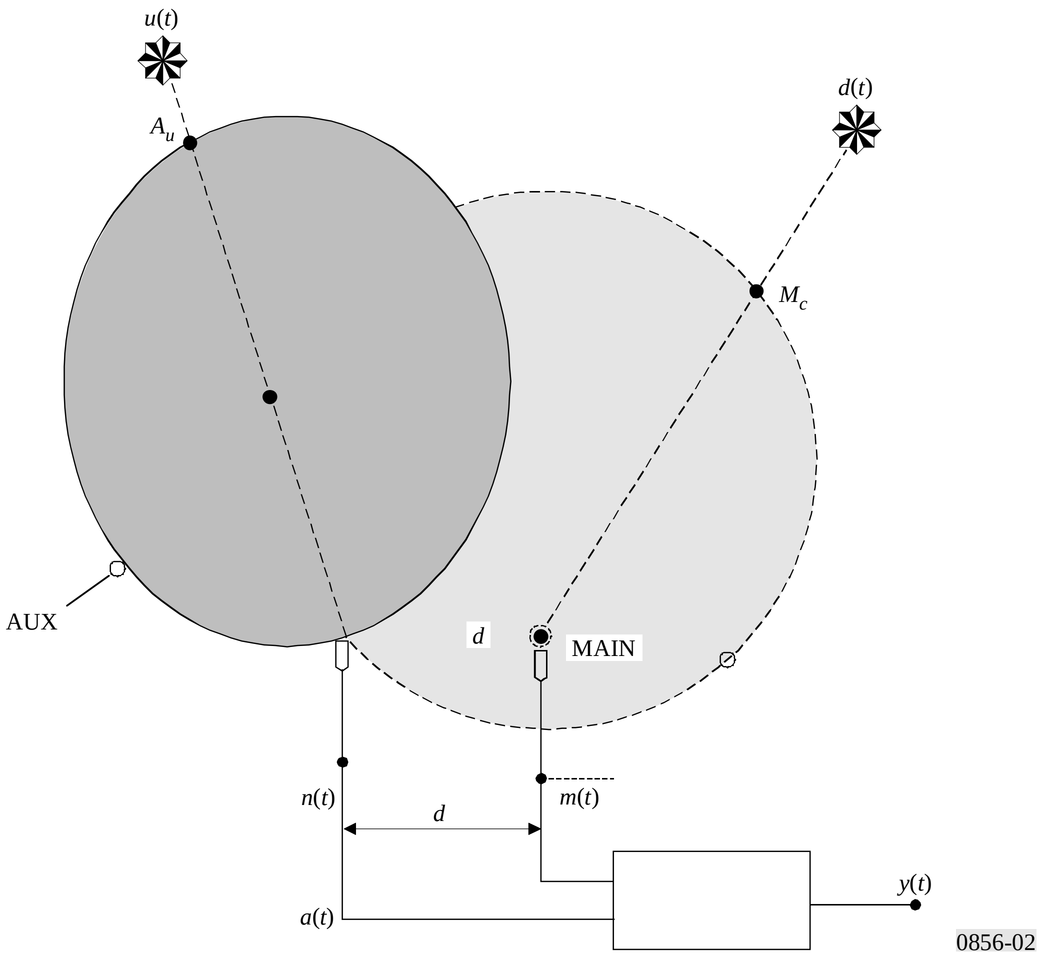

TABLE 1

Simplex LMR base station default parameters at VHF

Transmitter power	Minimum power received for the mobile, P_r	Base transmission/reception antenna		Mobile station antenna	
$P_t = 30$ W	10 log 10 $P_r = -139$ dBW	$h_t = 45$ m	$g_t = 0$ dB	$h_r = 2$ m	$g_r = 0$ dB
Local variability loss at VHF = 14 dB		Line losses = 0 dB		Line losses = 0 dB	

Using a simple low-angle, flat Earth propagation model, the approximate radius of the base station coverage, R, is computed from:

$$P_r = \frac{P_t \; g_t \; g_r \; (h_t \; h_r)^2}{R^4}$$

where:

P_r: minimum power received for the mobile

P_t: transmitter power

g_t, g_r: gain of the base station antenna and mobile station antennas, respectively

h_t, h_r: heights of the base station antenna and mobile station antennas, respectively.

The coverage area was plotted using a terrain data base and propagation modelling program which computes the interference signal strength from point-to-point calculations between two selected base stations. A mobile's desired signal is stepped through all azimuth angles in the coverage area along different signal strength contours corresponding to different received carrier powers at the base receiver, to map out the various coverage areas. The stand-alone coverage area is defined by the minimum signal strength contours. The jammed coverage contour corresponds to a signal strength 6 dB above the highest interference strength from any other base station. The adaptive base station antenna would be activated only when the mobile is between these contours. This corresponds to an area in which the *C*/*I* ratio of the base station is less than 6 dB, representing lost coverage. The adaptive antenna restores the coverage in this area, except in the angular sectors in the direction of the jamming base station.

4 Conclusions

Re-use distance was reduced by an average factor of 0.625 in the example scenario. In this study, when the additional co-channel base station is introduced, area computations showed that, without an adaptive antenna, each base station would lose one third of its coverage area due to interference from the others. But with an adaptive antenna only 7.6% of the coverage is lost. Substantial improvements in re-use distance may be achieved with simple suboptimal adaptive base station antennas in land mobile radio (LMR) in the VHF band. This type of adaptive array antenna has been developed into a product for cellular base stations. The promising results demonstrated in this study show that it can also be applied to land mobile radio systems. Hence reducing re-use distance between co-channel base stations can be achieved with today's technology. Simplex LMR systems were selected because an adaptive array antenna is a cost-effective near-term means of suppressing the resulting co-channel interference and is directly applicable in such systems.