EMC AND FREQUENCY SHARING ISSUES IN TETRA 2 TRUNKING NETWORKS

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ABSTRACT

The paper discusses frequency sharing and EMC problems between new TETRA 2 trunking systems based on TAPS technology and GSM land mobile networks. The carried out EMC analysis applied procedures for

- calculation of base station coverage radius when there is no interference,
- calculation of frequency-distance separations (FDS) under criterion of tolerable signal-to-noise ratio decrease on the boundary of coverage area.

Applying typical characteristics of radiocommunication equipment used in examined telecommunication networks both operating in the 900 MHz range there were defined conditions of frequency sharing and electromagnetic compatibility.

INTRODUCTION

TETRA is a based on digital technologies standard for trunking networks which main users are police, military, government organizations and commercial companies. In addition to general mobile communication services special features were implemented for professional user groups.

TETRA 2 presents an evolutionary enhancement to the existing TETRA standard, providing value added functionality to complement the many services and facilities already realized in previous version. At present new technology called TETRA Advanced Packet Service (TAPS) is under development. It will realize a high-speed packet data service based on the adaptation of existing standards to provide a TETRA overlay “data only” service. A new standard covers several frequency bands that can be occupied by TETRA 2 networks. The most attractive ranges for these systems in Europe were defined as 870-876 / 915-921 MHz.

One of the important issues for new system is electromagnetic compatibility with already existing telecommunication networks. For example, TETRA 2 trunking systems to be operating in the 900 MHz range will work in adjacent frequency bands with such land mobile networks, as GSM. The occurring EMC problems between two telecommunication systems can be successfully solved applying EMC analysis. It lies in calculation of frequency-distance separations between potentially incompatible transmitters and receivers of trunking and mobile networks.

PROCEDURE OF EMC ANALYSIS

The required FDS is a set of distance and frequency separations of interfering radioelectronic installations (REI), accounting antennas orientations that provide EMC between different networks. The particular operational frequencies, which can be used in mobile networks, or distance separations required for providing EMC for announced operational frequencies are determined on FDS base. Besides, FDS allow defining requirements to antennas orientations for a given operational frequencies and distances between REI. The FDS are calculated for particular REI types taking into account power, frequency and distance parameters. EMC between interfering REI (transmitter of one system and receiver of another) is ensured in case of complying with FDS requirements.

CRITERIA OF FDS CALCULATION

In the presence of interference a reception quality of wanted signal q is defined from the following relationship:

$$q = \frac{P_S}{P_N + P_I}, \tag{1}$$

where

P_S – wanted signal power at the receiver input (W);
P_N – noise power at the receiver input (W);
P_I – interference signal power at the receiver input (W).

Within a base station (BS) coverage area the following condition is valid:

$$q > Qk\sigma , \tag{2}$$

Here

Q – minimum value of q, ensuring normal receiver operation;

k – parameter accounting intolerable deterioration of communication quality;

σ – standard deviation characterizing fluctuations in wanted and interfering signal levels (for deployed in towns mobile networks σ = 4…7).

In the case of interference absence ($P_I = 0$) the radius R_S of coverage area will depend only on receiver's internal noise. On the boundary of coverage area

$$q = Qk\sigma = \frac{P_S}{P_N} . \tag{3}$$

Assuming $P_{MIN} = P_N$ Q as a receiver sensitivity, we obtain a wanted signal power as

$$P_S = P_N Qk\sigma = P_{MIN} k\sigma . \tag{4}$$

The signal-to-noise ratio (SNR) on the boundary of coverage area would decrease when interference signals would be observed ($P_I>0$). The same SNR value, as in the case of interference absence, would be achieved at the smaller distance R_I between transmitter and receiver. So, the coverage radius would also decrease ($R_I < R_S$).

In that way, when an interference signal appears a tolerable decrease of reception quality (SNR) on the boundary of coverage area can be assumed as criteria for FDS calculation:

$$q^* = \frac{1}{1 + P_N / P_I} . \tag{5}$$

First of all it's necessary to determine a coverage radius R_S when interference is absent. And after it, we shall determine a required separation D of interference source.

Calculation of Coverage Radius in the Absence of Interference

The dependence of signal power at the receiver input on channel parameters is defined by expression:

$$P_S = \frac{P_T G_T}{U_T} \frac{G_R}{U_R} \frac{1}{L(R)} , \tag{6}$$

where

P_T – interference signal transmitter power (W);

G_T – interference signal transmit antenna gain in direction to wanted signal receiver;

G_R – wanted signal receive antenna gain in direction to interference signal transmitter;

U_T , U_R – transmit and receive antennas feed loss;

L(R) – path loss on a distance of R from transmitter to receiver.

During the EMC analysis a path loss Hata model was used for urban areas and a free-space model for line-of-sight distances. Generally, these models looks like

$$L(R) = 10^{\alpha} R^{\beta} . \tag{7}$$

α, β – coefficients dependent on channel parameters (type of terrain, operational frequency and antenna heights).

From (4), (6) and (7) we obtain

$$k\sigma P_{MIN} = \frac{P_T G_T}{U_T} \frac{G_R}{U_R} \frac{1}{10^{\alpha} R^{\beta}} . \tag{8}$$

Then

$$R = 10^{\frac{z_S - \alpha_S}{\beta_S}} , \tag{9}$$

where z_S is a complex power parameter.

$$z_S = \lg \left[\frac{P_T G_T}{U_T} \frac{G_R}{U_R} \frac{1}{\mathrm{k}\sigma P_{MIN}} \right] . \tag{10}$$

The parameters z_S, α_S, β_S in (10) and (11) characterize the channel from wanted signal transmitter to receiver.

FDS Calculation under Criterion of Tolerable SNR Decrease on the Boundary of Coverage Area

On the boundary of coverage area (when receiver is separated from transmitter on distance R_S) and in the case of interference absence, SNR is determined by the (3).

In presence of interference signals this value would reduce in K_1 times,

$$q = \frac{P_S}{P_N + P_I} = k\sigma Q / K_1 . \tag{11}$$

As a signal power doesn't vary, the following expression is valid

$$P_N Q k\sigma = (P_N + P_I) Q k\sigma / K_1 . \tag{12}$$

Hence a tolerable value of interference signal power at the receiver input is

$$P_I = P_N (K_1 - 1) = P_{MIN} (K_1 - 1) / Q . \tag{13}$$

The dependence of interference signal power on path parameters is similar to (6).

$$P_N = \frac{P_T G_T}{U_T} \frac{G_R}{U_R} \frac{1}{10^{\alpha} D^{\beta}} \frac{1}{N(\delta f)} . \tag{14}$$

Here

D – distance from interfering transmitter to victim receiver;

N(δf) – interference signal attenuation ratio in a receiver linear section.

Equating the right parts of (13) and (14) and making transformations, we derive

$$D = 10^{\frac{z_I - \alpha_I}{\beta_I}} , \tag{15}$$

where generalized power parameter z_I is

$$z_I = \lg \left[\frac{P_T G_T}{U_T} \frac{G_R}{U_R} \frac{Q}{(\mathrm{K}-1) P_{MIN}} \frac{1}{N(\delta f)} \right] . \tag{16}$$

The parameters z_I, α_I, β_I in (16) and (17) characterize channel from interfering transmitter to receiver.

Frequency Sharing Conditions for TETRA 2 Trunking System and GSM Land Mobile Network

During the EMC analysis it was necessary to take into account antenna patterns of transmitters and receivers. Antenna can be oriented by main (M) or side (S) lobes. We have considered all 4 potential combinations:

M-M – the influence direction from the main lobe of interference source to the main lobe of the victim station;

M-S – the influence direction from the main lobe of transmitter to the side lobes of the receiver;

S-M – the influence direction from the side lobes of receiver to the main lobe of transmitter;

S-S – the influence direction from the side lobes of interference source to the side lobes of the victim station.

Taking into consideration technical characteristics of TETRA 2 and GSM-900 equipment it became clear that a most serious interference case is spurious and out-of-band emission of BS TETRA transmitter (915…921 MHz) to BS GSM receiver (890…915 MHz). The dependence of interference attenuation ratio in a receiver linear section on frequency offset for this case is presented on fig. 1.

The corresponding results of required separation distances calculation between radioelectronic installations for different frequency offsets and cases of mutual orientation of transmitter and receiver antenna patterns are shown in tables 1 and 2 accordingly for urban area and line-of-sight case. During a calculation the tolerable SNR decrease was taken equal to 3 dB.

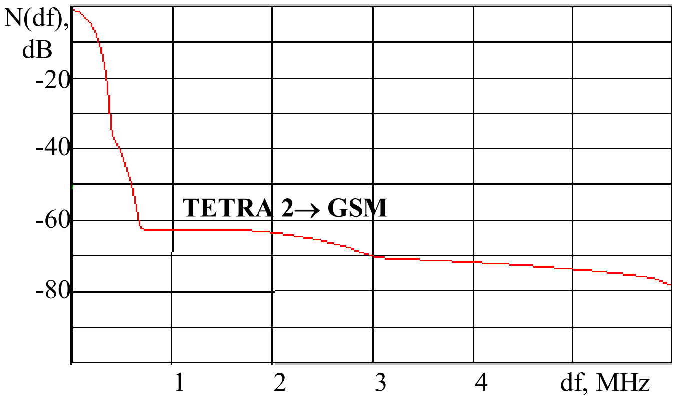

Fig. 1. Interference attenuation ratio.

Table 1. Required separations in an urban area, km

df, kHz	**0**	**200**	**400**	**600**	**1000**	**2000**	**4000**	**6000**
M-M	63,9	51,6	15,9	4,3	3,8	2,1	1,8	1,1
M-S	42,7	33,9	6,8	1,8	1,6	0,9	0,8	0,5
S-M	42,7	33,9	6,8	1,8	1,6	0,9	0,8	0,5
S-S	27,5	21,2	2,9	0,8	0,7	0,4	0,3	0,2

Table 2. Required separations in a line-of-sight case, km

df, kHz	**0**	**200**	**400**	**600**	**1000**	**2000**	**4000**	**6000**
M-M	> 100	> 100	> 100	61,2	48,6	17,2	13,7	5,5
M-S	> 100	> 100	> 100	13,7	10,9	3,9	3,1	1,2
S-M	> 100	> 100	> 100	13,7	10,9	3,9	3,1	1,2
S-S	> 100	> 100	30,7	3,1	2,4	0,9	0,7	0,3

CONCLUSIONS

The analysis of obtained results shows that frequency sharing of TETRA 2 and GSM networks is possible in urban area applying 2 MHz frequency offset and not less than 2 km distance separation. When Rx and Tx antennas are not oriented by main lobes the distance separation can be about 900 m.

In a line-of-sight case and M-M orientation a frequency sharing is possible applying 6 MHz frequency offset and not less than 5,5 km distance separation. When Rx and Tx antennas are not oriented by main lobes the distance separation can be about 1,2 km.

The obtained values of required frequency-distance separations between the radioelectronic installations are of great practical importance to the possible estimation of frequency allocations to new TETRA 2 systems in Russia and other countries.

Recommendations from this paper can also be included into appropriate agreements between administrations of neighboring countries concerning the use of the frequency bands in border areas.

The originality of the contribution lies in estimation of potential for TETRA 2 networks deployment on the territory of the Russia Federation and other European countries under the conditions of possible interference from existing telecommunication networks, such as GSM systems.

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