RECOMMENDATION ITU-R SM.669-1

# PROTECTION RATIOS FOR SPECTRUM SHARING INVESTIGATIONS

(Question ITU-R 45/1)

(1990-1994)

The ITU Radiocommunication Assembly,

*considering*

a) that frequency sharing is an important aspect of efficient spectrum utilization;

b) that the Radiocommunication Assembly has placed a principal responsibility for the study of frequency sharing problems with Radiocommunication Study Group 1 in coordination with other Study Groups;

c) that Radiocommunication Study Group 1 is cognizant of the work within the various Radiocommunication Study Groups on frequency sharing;

d) that frequency sharing may have a much wider potential applicability than so far reflected in its practical use;

e) that Radiocommunication Study Group 1 is studying sharing problems common to two or more Radiocommunication Study Groups in coordination with those groups;

f) that it is desirable to determine the level of interference at which any emission, radiation or induction affects a radio service in order to derive criteria for frequency sharing, and that one method of specifying these interference levels is in terms of protection ratios;

g) that the ITU-T Recommendations establish noise and interference criteria for the public switched network, that could be affected by spectrum sharing situations,

*recommends*

**1.** that protection ratios provided by modulation type in Table 1 are appropriate for spectrum sharing investigations unless more detailed technical information is available;

**2.** that in sharing situations involving radio circuits interconnected to the public switched network appropriate ITU-T criteria should also be taken into account;

**3.** that protection ratios derived by other ITU-R Recommendations given in Table 2 are appropriate for spectrum sharing investigations when the data of Table 1 is not applicable.

TABLE 1

**Protection ratios (dB)**

| Interference → / ↓ Wanted signal | | Emission class | 500HA1B | | | 6K00A2B | | | 6K00A3E | | | 3K00A3E | | | 5M00C3F | | | 7M00C3F-8M00C3F | | | 1K10F1B | | | 16K0F3E | | | 726KF8E | | | 1M32P0N | | | Noise | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Parameters | 100 Bd PW = 10 ms | | | $m_f$ = 1 | | | $m_f$ = 0.3 | | | | | | 525 lines | | | 625 lines | | | 50 Bd PW = 10 ms | | | | | | 24 channels | | | PW = 5 µs PRF = 300 pps | | | White Gaussian noise | | |
| Emission class | Parameters | Performance level (1) | CO | OFF | Note | CO | OFF | Note | CO | OFF | Note | CO | OFF | Note | CO | OFF | Note | CO | OFF | Note | CO | OFF | Note | CO | OFF | Note | CO | OFF | Note | CO | OFF | Note | CO | OFF | Note |
| 500HA1B | $BW_{IF}$ = 500 Hz, 50 Bd<br>$(S/N)_I$ = 18 dB | $P_E = 10^{-2}$ | 11 | | 3 | | | | 6 | | 4 | 14 | | 4 | | | | | | | 12 | | 3 | 8 | | 4 | | | | | | | | | |
| | | $P_E = 10^{-4}$ | 12 | | 3 | | | | 7 | | 4 | | | | | | | | | | 13 | | 3 | 11 | | 4 | | | | | | | | | |
| | | $P_E = 10^{-6}$ | 13 | | 3 | | | | 8 | | 4 | | | | | | | | | | 14 | | 3 | 13 | | 4 | | | | | | | | | |
| 6K00A2B | $BW_{IF}$ = 8 kHz<br>$m_s$ = 1.0<br>$(S/N)_I$ = 18 dB | $P_E = 10^{-2}$ | 4 | | 1 | | | | 5 | | 1 | | | | | | | | | | | | | 4 | | 1 | | | | | | 6 | – | 1 |
| | | $P_E = 10^{-4}$ | 4 | | 1 | | | | 5 | | 1 | | | | | | | | | | | | | 4 | | 1 | | | | | | 9 | – | 1 |
| | | $P_E = 10^{-6}$ | 4 | | 1 | | | | 5 | | 1 | | | | | | | | | | | | | 4 | | 1 | | | | | | | – | 1 |
| 6K00A3E(2) | $BW_{IF}$ = 8 kHz<br>$\Delta f$ = 0.5 kHz<br>$m_s$ = 0.3<br>$(S/N)_I$ = 45 dB | MINIT | 44 | 61 | 1 | | | | 43 | 48 | 1 | 50 | 50 | 1 | | | | | | | 47 | 55 | 1 | 48 | | 1 | | | | 20 | 10 | 1 | | | |
| | | 0.7 AI | 4 | 8 | 1 | | | | 7 | 8 | 1 | 17 | 14 | 1 | | | | | | | 3 | 8 | 1 | 19 | | 1 | | | | –17 | –22 | 1 | 21 | – | 1 |
| | | 0.3 AI | –7 | –2 | 1 | | | | 2 | 3 | 1 | 6 | 3 | 1 | | | | | | | –2 | 4 | 1 | 8 | | 1 | | | | –30 | –37 | 1 | 10 | – | 1 |
| | | GCQ | 39 | 35 | 2 | | | | 32 | 42 | 2 | 44 | 43 | 2 | | | | | | | 37 | 41 | 2 | 40 | | 2 | | | | –3 | –2 | 2 | 41 | – | 2 |
| | | MCQ | 21 | 20 | 2 | | | | 14 | 24 | 2 | 26 | 25 | 2 | | | | | | | 19 | 23 | 2 | 22 | | 2 | | | | –15 | –20 | 2 | 23 | – | 2 |
| | | JUQ | 12 | 11 | 2 | | | | 5 | 15 | 2 | 17 | 16 | 2 | | | | | | | 10 | 15 | 2 | 13 | | 2 | | | | –24 | –28 | 2 | 14 | – | 2 |
| 3K00J3E or 3K00R3E | $BW_{IF}$ = 2.7 kHz<br>$\Delta f$ = 0.5 kHz<br>$(S/N)_I$ = 35 dB | MINIT | 25 | 42 | 1 | | | | 20 | 20 | 1 | 42 | 41 | 1 | | | | | | | 30 | 40 | 1 | 35 | | 1 | 38 | | 1 | 1 | | 1 | | – | – |
| | | 0.7 AI | –14 | –8 | 1 | | | | –14 | –5 | 1 | 3 | 4 | 1 | | | | | | | –25 | –12 | 1 | 3 | | 1 | 0 | | 1 | –38 | | 1 | 9 | – | 1 |
| | | 0.3 AI | –28 | –24 | 1 | | | | –28 | –19 | 1 | –12 | –16 | 1 | | | | | | | –43 | –37 | 1 | –10 | | 1 | –12 | | 1 | –52 | | 1 | –3 | – | 1 |
| | | GCQ | 10 | 27 | 2 | | | | 13 | 30 | 2 | 31 | 32 | 2 | | | | | | | 21 | 30 | 2 | 27 | | 2 | 26 | | 2 | –15 | | 2 | 32 | – | 2 |
| | | MCQ | –8 | 9 | 2 | | | | –5 | 12 | 2 | 13 | 14 | 2 | | | | | | | 3 | 12 | 2 | 9 | | 2 | 8 | | 2 | –33 | | 2 | 14 | – | 2 |
| | | JUQ | –17 | 0 | 2 | | | | –14 | 3 | 2 | 4 | 5 | 2 | | | | | | | –6 | 3 | 2 | 0 | | 2 | –1 | | 2 | –42 | | 2 | 5 | – | 2 |
| 5M00C3F | $BW_{IF}$ = 6 MHz, 525 lines<br>$(S/N)_I$ = 46 dB | TASO 2.5 | | | | 50 | 15 | 5 | 50 | 15 | 5 | | | | 47 | 25 | 5 | | | | | | | 50 | 15 | 5 | | | | | | | | | |
| 7M00C3F-8M00C3F | $BW_{IF}$ = 6 MHz, 625 lines<br>$(S/N)_I$ = 46 dB | ITU-R 4 | | | | | | | 58 | – | 6 | | | | | | | 52 | – | 6 | | | | | | | | | | | | | | | |
| | | ITU-R 3 | | | | | | | 51 | – | 6 | | | | | | | 45 | – | 6 | | | | | | | | | | | | | | | |
| 1K10F1B | $BW_{IF}$ = 1 050 Hz<br>$D_{PK}$ = ± 425 Hz<br>50 Bd $(S/N)_I$ = 18 dB | $P_E = 10^{-2}$ | 0 | | 1 & 3 | | | | 2 | | 1 | 10 | | 4 | | | | | | | 6 | | 3 | 0.5 | | 1 | | | | –50 | | 1 | 9 | – | 1 |
| | | $P_E = 10^{-4}$ | 0 | | 1 & 3 | | | | 3 | | 1 | 13 | | 4 | | | | | | | 7 | | 3 | 1 | | 1 | | | | –49 | | 1 | 13 | – | 1 |
| | | $P_E = 10^{-6}$ | 1 | | 1 & 3 | | | | 3 | | 1 | 15 | | 4 | | | | | | | 8 | | 3 | 2 | | 1 | | | | –48 | | 1 | 15 | – | 1 |
| 16K0F3E (2) | $BW_{IF}$ = 16 kHz<br>$D_{PK}$ = 5 kHz<br>$\Delta f$ = 0.5 kHz<br>De-emphasis<br>$(S/N)_I$ = 22 dB | MINIT | 38 | 38 | 1 | | | | | | | | | | | | | | | | 33 | 33 | 1 | 31 | 31 | 1 | 32 | 32 | 1 | –11 | | 1 | –1 | – | – |
| | | 0.7 AI | 0 | 0 | 1 | | | | | | | | | | | | | | | | 2 | 2 | 1 | 2 | 2 | 1 | 4 | 4 | 1 | –24 | | 1 | 1 | | 1 |
| | | 0.3 AI | 0 | 0 | 1 | | | | | | | | | | | | | | | | 0 | 0 | 1 | –5 | –5 | 1 | 0 | 0 | 1 | | | | 0 | – | 1 |
| | | GCQ | 13 | 13 | 2 | | | | | | | | | | | | | | | | 15 | 15 | 2 | 14 | 14 | 2 | 16 | 16 | 2 | | | | 11 | – | 2 |
| | | MCQ | 2 | 2 | 2 | | | | | | | | | | | | | | | | 3 | 3 | 2 | 1 | 1 | 2 | 4 | 4 | 2 | | | | 5 | – | 2 |
| | | JUQ | –1 | –1 | 2 | | | | | | | | | | | | | | | | 1 | 1 | 2 | 0 | 0 | 2 | 1 | 1 | 2 | | | | 2 | – | 2 |
| 726KFBE(3) | 24 channels<br>Upper channel<br>$\Delta f$ = 44.5 kHz<br>$(S/N)_I$ = 45 dB | MINIT | 47 | 60 | 1 | | | | 55 | 64 | 1 | | | | | | | | | | 55 | 60 | 1 | 55 | 60 | 1 | 46 | 57 | 1 | 25 | 20 | 1 | – | – | – |
| | | 0.7 AI | 3 | 12 | 1 | | | | 4 | 14 | 1 | | | | | | | | | | 6 | 14 | 1 | 12 | 18 | 1 | 2 | 5 | 1 | | –34 | 1 | 9 | – | 1 |
| | | 0.3 AI | 0 | –15 | 1 | | | | 0 | 4 | 1 | | | | | | | | | | 2 | 6 | 1 | 2 | 6 | 1 | 1 | –3 | 1 | | –39 | 1 | 1 | – | 1 |
| | | GCQ | 24 | | 2 | | | | 25 | | 2 | | | | | | | | | | 29 | | 2 | | | | 29 | | 2 | | | | 31 | | 2 |
| | | MCQ | 6 | | 2 | | | | 7 | | 2 | | | | | | | | | | 11 | | 2 | | | | 9 | | 2 | | | | 13 | – | 2 |
| | | JUQ | 2 | | 2 | | | | 2 | | 2 | | | | | | | | | | 5 | | 2 | | | | 4 | | 2 | | | | 4 | – | 2 |

*Notes to Table 1*

(1) PE: probability of error

MINIT: minimum interference threshold

AI: articulation index

GCQ: good commercial quality

MCQ: marginal commercial quality

JUQ: just usable quality

TASO: Television Allocation Study Organization scoring grades

ITU-R (ex-CCIR): Study Group 11 impairment scale of 1-5

CO: co-channel where frequency separation is zero

OFF: off channel separation given by $\Delta f$

$\Delta f$: frequency separation between wanted and interference signals.

(2) For broadcasting, see Table 2 of other protection ratio references. Numbers in this Table for A3E and J3E versus noise are 2 dB higher than values in Recommendation ITU-R F.339, due to different modulation specifications.

(3) Single link only, for multi-link terrestrial microwave radio relay, see ITU-R F Series Recommendations.

*Note 1* – OT/ECAC [August, 1975] Communications/Electronics Receiver Performance Degradation Handbook. The Frequency Management Support Division, Office of Telecommunications (OT), United States Department of Commerce (DOC) and the Electromagnetic Compatibility Analysis Center (ECAC), ESD-TR-75-013. (Available from US DOC National Technical Information Service (NTIS), Springfield, VA, USA, Order No. AD-A016400.)

*Note 2* – Obtained from transfer curves used in the Handbook described in Note 1.

*Note 3* – Extrapolated from Recommendation ITU-R F.240.

*Note 4* – MAYHER, R. [1972] Interference Performance Degradation to Digital Systems. Record of the 1972 IEEE International EMC Symposium.

*Note 5* – Extrapolated from ex-CCIR Recommendation 418-3 (Geneva, 1982).

*Note 6* – Evaluated in accordance with Recommendations ITU-R BT.500 and ITU-R BO.600.

$m_I$: modulation index of interfering signal

PW: pulse width

PRF: pulse repetition frequency

BW: bandwidth

$m_s$: modulation index of desired signal.

TABLE 2

**Protection ratio references from other Radiocommunication Study Groups**

| Volume | Recommendation[1] | Notes |
|---|---|---|
| III | Recommendation ITU-R F.240 | Many PRs including fading |
| VIII | Recommendation ITU-R M.589 | Radionavigation PR |
| VIII | Recommendation ITU-R M.631 | Phased radionavigation PR |
| VIII | Recommendation ITU-R M.441 | Aero. mobile (R) (ICAO An.10) |
| X-1 | Recommendation ITU-R BS.638 | Sound RF/AF PRs |
| X-1 | Recommendation ITU-R BS.560 | Sound, LF, MF, HF PRs |
| X-1 | Recommendation ITU-R BS.641 | FM sound PRs |
| X-1 | Recommendation ITU-R BS.412 | FM sound/VHF PRs |
| X/XI-2 | Recommendation ITU-R BO.566 | Broadcast PR definitions |
| XI-1 | Recommendation ITU-R BT.655 | AM TV PRs |
| XI-1 | Recommendation ITU-R BT.565 | 625 TV/RN, 582-606 MHz PRs |

(1) Ensure that the latest version of the Recommendation is obtained.