RECOMMENDATION ITU-R F.1402*, **

FREQUENCY SHARING CRITERIA BETWEEN A LAND MOBILE WIRELESS ACCESS SYSTEM AND A FIXED WIRELESS ACCESS SYSTEM USING THE SAME EQUIPMENT TYPE AS THE MOBILE WIRELESS ACCESS SYSTEM

(Questions ITU-R 215/8 and ITU-R 140/9)

(1999)

1 Introduction

Nowadays, technology of land-mobile systems is used for fixed wireless access (FWA) systems. Such FWA systems are becoming popular and implemented at a remarkable speed, since large demands for mobile communications bring about economical equipment production for this application. In this Recommendation, a land mobile system is called mobile wireless access (MWA) system, and the FWA system that utilizes the same type of equipment as the MWA is called MWA-based FWA system or simply FWA system. These terminologies are based on Recommendation ITU-R F.1399.

In most cases, such FWA systems are designed in the same frequency band as the MWA systems to enhance the manufacturing efficiency. Therefore it is an urgent and critical subject to study the sharing criteria, particularly necessary geographical separation, between both systems.

Such criteria is needed when one administration wishes to utilize the frequency band with dual allocations (i.e. to the fixed and the mobile services) for both FWA and MWA applications in certain geographical separation.

Recommendation ITU-R F.1334 presents a statistical technique for calculating interference conditions for the cases that the land-mobile system and fixed system use different types of equipment from each other. With the purview of providing complementary information, this Recommendation mainly describes interference between an MWA system and an FWA system using the same type of equipment with the same design parameters.

2 Scope

This Recommendation describes the frequency sharing criteria between the FWA and MWA systems on the assumption that both systems use the same frequency and type of equipment. Necessary geographical separations between both systems are calculated for the cases that the systems employ time division duplex (TDD) or frequency division duplex (FDD).

3 References

Recommendation ITU-R F.1334: Protection criteria for systems in the fixed service sharing the same frequency bands in the 1 to 3 GHz range with the land mobile service;

Recommendation ITU-R F.1399: Vocabulary of terms for wireless access;

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* This Recommendation was developed jointly by Radiocommunication Study Groups 8 (Working Party 8A) and 9 (Working Party 9B), and any further revision should also be undertaken jointly.

** This draft new Recommendation should be brought to the attention of Radiocommunication Study Groups 3 (Working Party 3K) and 8 (Working Party 8A).

4 Recommendation

4.1 Interference model

The prerequisites for setting an interference model are as follows:

– The MWA and FWA system use equipment with the same specifications.

– The MWA and FWA systems are point-to-multipoint systems.

– The MWA and FWA systems employ either TDD or FDD for duplexing.

Figure 1 shows an interference model, where various interference can be classified into the following eight types:

Case I : MWA system is interfered-with side

– I-a) FWA base station ⇒ MWA user station

– I-b) FWA user station ⇒ MWA user station (TDD system only)

– I-c) FWA user station ⇒ MWA base station

– I-d) FWA base station ⇒ MWA base station (TDD system only)

Case II : FWA system is interfered-with side

– II-a) MWA base station ⇒ FWA user station

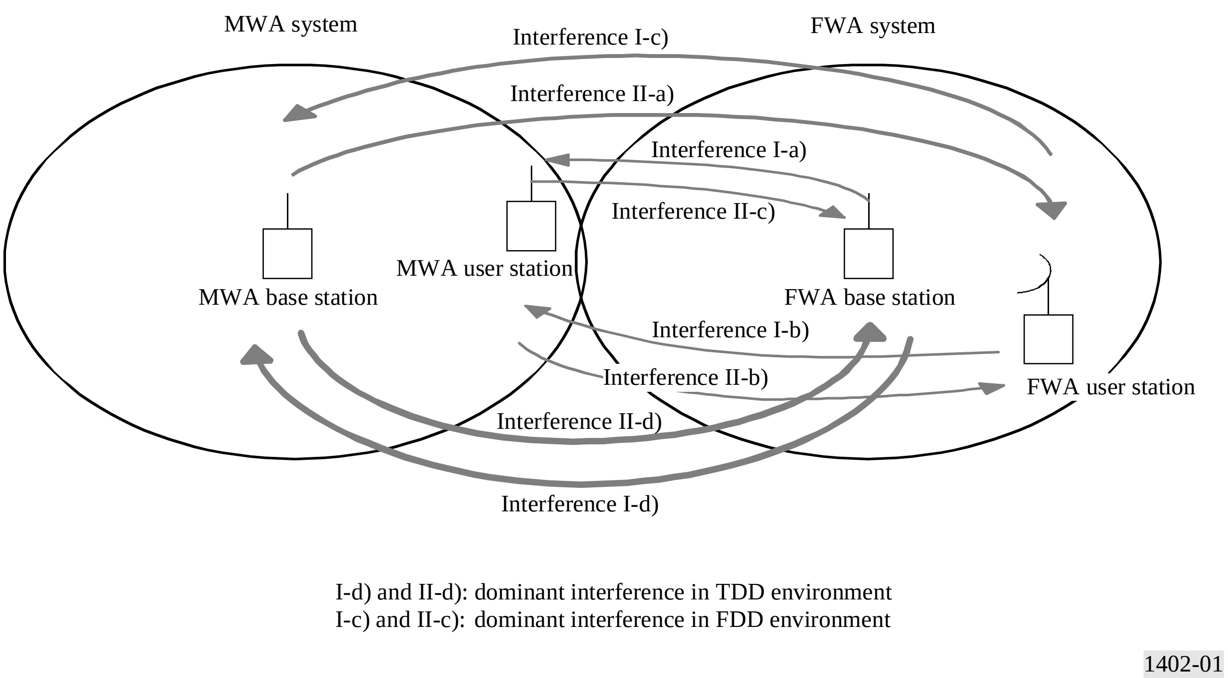
– II-b) MWA user station ⇒ FWA user station (TDD system only)

– II-c) MWA user station ⇒ FWA base station

– II-d) MWA base station ⇒ FWA base station (TDD system only).

FIGURE 1

Interference model



4.2 Dominant interference

If the service areas of the FWA and MWA systems are fully separated from each other, the greatest factor determining interference level is not an individual position of the stations, i.e. the distance between the interference source and the interfered-with equipment. Interference level depends on the transmit output power, antenna gain, antenna height and the direction of the antenna main beam.

It is assumed that in the above eight types of interference the line-of-sight path is maintained with no obstacles. Concerning the antenna type only FWA user stations employ directive antennas, while other three kinds of stations use omnidirectional or sectorized type.

In Case I for FDD environment, interference I-c) is considered to be more critical than interference I-a), because FWA user station has directive antenna. Similar consideration is applied in Case II for FDD environment.

In case I for TDD environment, interference I-d) is considered to be more critical than interference I-c), because the FWA base station is located at a higher point so that it covers the area, and the propagation condition between MWA base station and FWA base station is better than that between MWA base station and FWA user station. Similar consideration is applied in Case II for FDD environment.

Consequently, the sharing criteria should be determined by considering the following dominant interference:

a) *Case I*:

– TDD environment: I-d) FWA base station ⇒ MWA base station

– FDD environment: I-c) FWA user station ⇒ MWA base station.

b) *Case II*:

– TDD environment: II-d) MWA base station ⇒ FWA base station

– FDD environment: II-a) MWA base station ⇒ FWA user station.

It should be noted that the same combination of interference with opposite direction, i.e. I-d) and II-d), or I-c) and II-a), will result in the same level since MWA and FWA use the same system parameters.

Moreover, it should be noted that if the synchronization of TDD transmission within the system and with the interfering system is achieved in TDD environment, the combination for FDD environment can be applied.

In the above interference a directive antenna at an FWA user station is oriented toward the MWA base station. In addition the worst case is assumed when an FWA user station is located near the FWA base station.

4.3 Protection criteria for MWA systems from FWA system interference

4.3.1 Conditions under TDD environment

The interference level I (dBm) (median value) at the MWA base station can be calculated as follows:

$$I = P_{tC} - L_{fC} - L_{fB} + G_C + G_B - L \qquad (1)$$

where:

L: propagation loss (dB)

P_{tC}: transmit power of FWA base station (dBm)

L_{fC}: feeder loss of FWA base station (dB)

L_{fB}: feeder loss of MWA base station (dB)

G_C: antenna gain of FWA base station (dBi)

G_B: antenna gain of MWA base station (dBi).

Then, the maximum allowable interference level for the MWA system can be calculated as follows:

$$I < N_B + X \qquad (2)$$

where:

N_B: thermal noise level at the MWA receiver (dBm)

X: allowable relative (I/N) ratio at the long term criteria (dB).

X indicates the allowable interference compared with the thermal noise. For the MWA system operating at a threshold related to the thermal noise, it is required that the mutual influence of MWA and FWA is minimal (say, 1 dB); in this case the interference must be approximately 6 dB below thermal noise, and X will be around –6 dB.

In some cases, the mutual influence of MWA and FWA can be the same level as thermal noise to improve the geographically efficient sharing, and in this case X will be around 0 dB.

Another possible approach for the frequency sharing is that some level of interference is accepted for both MWA and FWA, because this system has the interference avoidance functions. Although the traffic capacity may be reduced, the system can be operated even when there is some interference. In this case, X can be greater than 0 dB and the separation distance will become shorter.

In the link design of FWA systems, L is usually calculated from the free-space propagation when sufficient Fresnel radius is obtained. On the other hand, in case of MWA systems a different approach may be adopted. It is very likely that the propagation path with sufficient Fresnel radius is not obtained for each interference path in Fig. 1. In such cases propagation loss greater than the free-space propagation is anticipated. Suppose that the propagation loss at the distance d is expressed by $L(d)$, the minimum distance d_{min} between both stations is given by the following formula derived from formulas (1) and (2):

$$L(d_{min}) = P_{tC} - L_{fC} - L_{fB} + G_C + G_B - (N_B + X) \qquad (3)$$

4.3.2 Conditions under FDD environment

Under the FDD environment, the minimum distance d_{min} between both stations can be calculated for different dominant interference but in the same way as follows;

$$L(d_{min}) = P_{tS} - L_{fS} - L_{fB} + G_S + G_B - (N_B + X) \qquad (4)$$

where:

- P_{tS} : transmit power of FWA user station (dBm)
- L_{fS} : feeder loss of FWA user station (dB)
- G_S : antenna gain of FWA user station (dBi).

4.4 Protection criteria for FWA systems from MWA system interference

The protection criteria for FWA systems from MWA system interference can be derived from the results in the previous section. As mentioned before, in Case II the interference levels of II-d) and II-a) are equivalent to those of I-d) and I-c) in Case I.

4.5 Examples of the calculation

Examples of the interference calculation based on the actual system are shown in Annexes 1 and 2.

ANNEX 1

Examples of calculation of interference conditions in the 1.9 GHz band

The example below shows how to calculate the conditions between a personal handy-phone system (PHS) and PHS-FWA (or PHS-WLL (wireless local loop)) in the 1.9 GHz band (TDD environment). Even under other environments, similar results will be obtained by changing the parameters.

PHS technology employs dynamic channel assignment (DCA). By using this technology, more than one system, possibly operated by different operators, share the same radio channels avoiding the use of the same frequency at each time slot.

Therefore, it is technically feasible for an FWA and an MWA with DCA to share the same frequency band in the same area. However, in this calculation, the existence of the DCA function is not considered, as in real systems. Instead, only the ordinary sharing conditions, in which two systems use the same frequency, accepting a certain level of degradation by mutual interference, are examined.

In this example, the interference from PHS-FWA to PHS conditions are calculated on the assumption that the conditions from PHS-FWA to PHS and the conditions from PHS to PHS-FWA are symmetrical in radio path design.

1 Calculating the necessary propagation loss

System parameters for assumed FWA base station and MWA base station are given in Table 1.

TABLE 1

Assumed system (FWA base station and MWA base station)

Parameter	Contents
Interface	R2
System	PHS to PHS-FWA
Access/duplex method	TDMA/TDD
Number of slots	4
Transmit power P_{tC}	13 dBm (average)/22 dBm (peak)
Bandwidth	300 kHz
Noise figure	10 dB
Noise floor	–109 dBm
Antenna gain, G_C, G_B	10 dBi
Feeder loss, L_{fC}, L_{fB}	1 dB
Height of feeder point, h_C, h_B	10 m
Allowable I/N ratio	X dB

The necessary propagation loss for the system assumed in Table 1 will be as follows, based on equation (3):

$$\begin{aligned} L(d_{min}) &= P_{tC} - L_{fC} - L_{fB} + G_C + G_B - (N_B + X) \\ &= 22 - 1 - 1 + 10 + 10 - (-109 + X) \\ &= 149 - X \qquad \text{dB} \end{aligned} \tag{5}$$

2 Calculating the separation distance

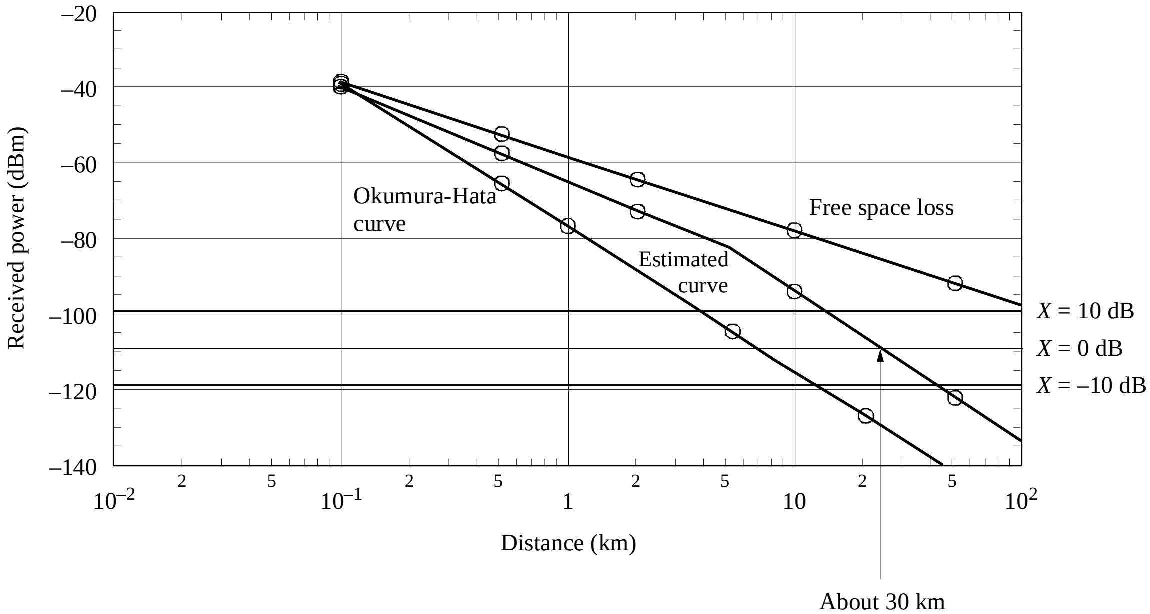
Assuming the coexistence of the MWA system mainly in an urban area and the FWA system mainly in a rural area, the separation distance is calculated using the propagation loss characteristics in a rural area.

The Appendix 1 to Annex 1 shows the concept of estimating the propagation characteristics in rural area.

In Fig. 2, the separation distance is calculated using the estimated curve of the received power distance characteristics shown in Fig. 4. The separation distance will be about 30 km at $X = 0$ dB.

FIGURE 2

Calculation of separation distance



Note 1 – h_C is out of its application range (30-200 m) in Okumura-Hata curve.
Adjustment based on the topographical and building conditions is not considered.

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APPENDIX 1

TO ANNEX 1

Propagation characteristics in the 1.9 GHz band in rural areas*

1 Short-distance propagation characteristics in rural area

The propagation loss increased from the free-space loss in 1.9 GHz band was calculated from the measured propagation loss in a comparatively flat and open land where only houses and small-scale groves exist on the propagation route. With the transmitting antenna height, receiving antenna height, and transmission distance as parameters, the additional propagation loss was calculated using the following experimental formula:

$$L_a = [52.53 - 36.45 \log (h_t + h_r)] \log d + 61.93 \log (h_t + h_r) - 89.24 \qquad (6)$$

where:

L_a: additional propagation loss (not including a free-space loss) (dB)

h_t: transmitting antenna height (m) (about 10 m to 20 m)

h_r: receiving antenna height (m) (about 2 m to 10 m)

d: transmission distance (m)

maximum value for $(h_t + h_r)$ is 25 m.

The experimental formula of (6) is applicable to short-distance propagation from about 100 m up to about 5 km.

* Propagation characteristics proposed in this Appendix and the applicability of formulae (6) and (7) applicable to frequency bands other than 1.9 GHz should be further reviewed in the work of Radiocommunication Study Group 3 (Working Party 3K).

2 Long-distance propagation characteristics in rural areas

According to the long-distance propagation characteristics in an extremely open area where there are no obstacles on the propagation route, the propagation loss is proportional to the square of the distance up to the break point, B_p, and almost the fourth power of the distance over B_p.

For calculating B_p, formula (7) is assumed:

$$B_p = \frac{4 h_t h_r}{\lambda k_f^2} \tag{7}$$

where:

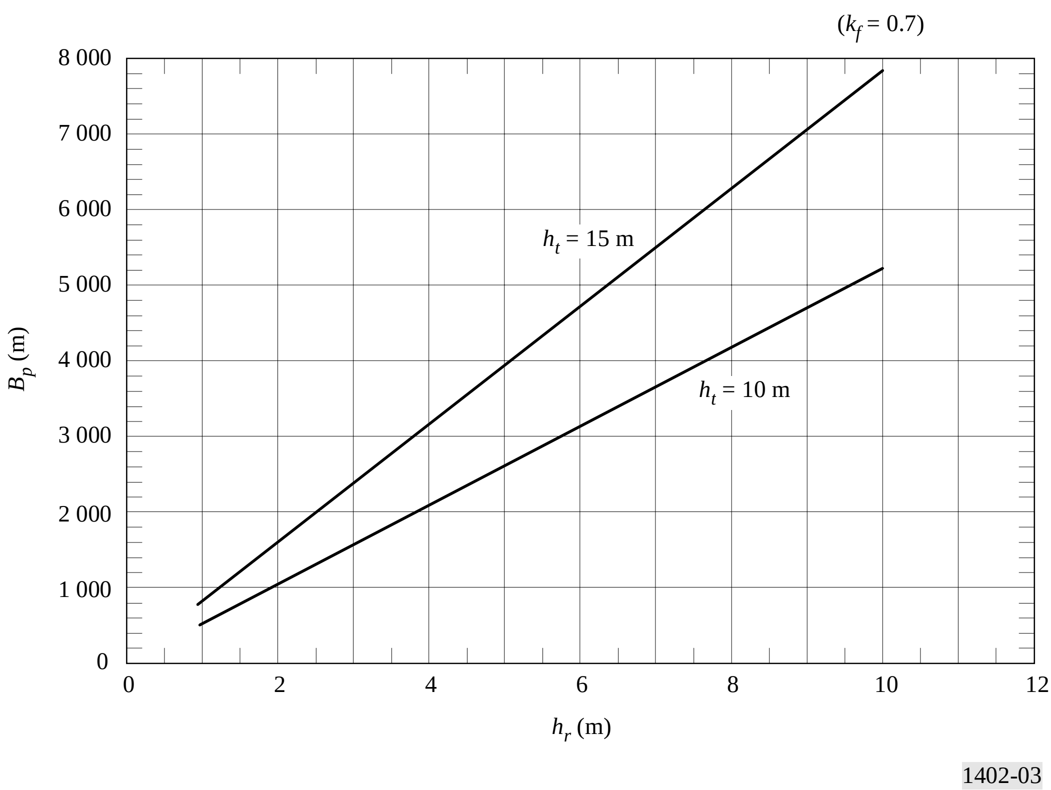
k_f: fresnel radius factor

λ: wavelength.

Fig. 3 shows B_p calculated from h_r and h_t.

FIGURE 3

Calculation of B_p



3 Estimation of propagation loss in rural areas

3.1 Propagation loss estimation method

Considering the above results, the propagation loss in a comparatively flat and open land where only houses and small-scale groves exist on the propagation route can be estimated as follows:

Step 1 : calculate B_p using formula (7) ($k_f = 0.7$).

Step 2 : when the propagation distance is up to B_p ($d \leq B_p$):

$$L = L_a + L_0$$

Where:

L : total propagation loss (dB)

L_a : additional propagation loss (dB) calculated using formula (6)

L_o : free-space propagation loss (dB).

Step 3 : When the propagation distance is beyond B_p ($B_p < d$):

L (dB) = L (dB), at $B_p + 40 \log (d/B_p)$.

3.2 Example of estimating received power versus distance characteristics

When the transmitted power is 22 dBm (peak), the transmitting antenna gain is 10 dBi, the transmitting power feed loss is 1 dB, the transmitting antenna height is 10 m, the receiving antenna gain is 10 dBi, the received power feed loss is 1 dB, and the transmitting antenna height is 10 m, the received power distance characteristics can be calculated as follows:

The received power P_r at the B_p will be as follows:

$$B_p = (4 \times 10 \times 10)(0.158 \times 0.7^2)$$
$$= 5166.7 \text{ m}$$

$$L_a(d = B_p) = [52.53 - 36.45 \log (10 + 10)] \log (5166.7) + 61.93 \log (10 + 10) - 89.24$$
$$= 10.3 \quad \text{dB}$$

$$L_0(d = B_p) = 20 \log (4 \times \pi \times 5166.7/0.158)$$
$$= 112.3 \quad \text{dB}$$

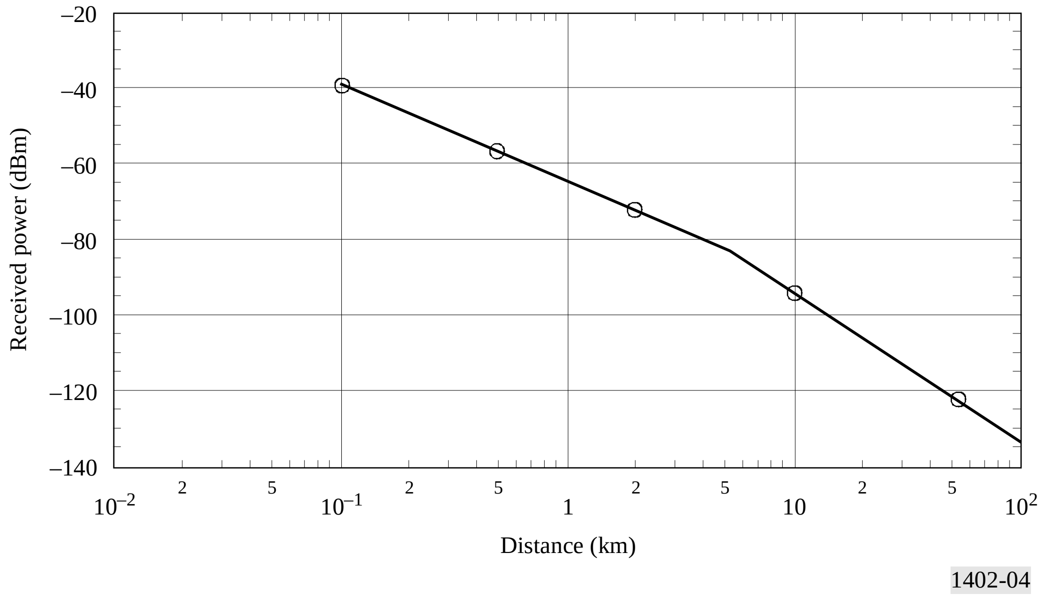
$$L(d = B_p) = L_a(d = B_p) + L_0(d = B_p) = 10.3 + 112.3$$
$$= 122.6 \quad \text{dB}$$

$$P_r(d = B_p) = 22 + 10 - 1 + 10 - 1 - L$$
$$= 22 + 10 - 1 + 10 - 1 - 122.6$$
$$= -82.6 \quad \text{dBm} \qquad (8)$$

Fig. 4 shows the estimated curve for the received power characteristics.

FIGURE 4

Estimated distance characteristics of received power in a rural area



ANNEX 2

Examples of calculation of interference conditions in the 800 MHz band

The example below shows how to calculate the conditions between personal digital cellular (PDC) and PDC-FWA (or PDC-WLL) in the 800 MHz band (FDD environment). Even under other environments, similar results will be obtained by changing the parameters.

Compared with the cordless type systems discussed in Annex 1, PDC/PDC-FWA has the following characteristics:

– FDD access scheme is employed;

– the transmit power is higher, and the base station antenna is located at a higher point, and so the base station covers a larger area;

– since a PDC base station which covers a wider area typically up to about 50 km interferes with the FWA system, the propagation curve usually applied for a cellular mobile system can be applied when estimating interference.

(On the contrary, in cordless systems, an MWA base station covers a smaller area, such as several hundred metres, and the MWA base station which may cause interference to FWA are located near a rural area and the different propagation curve is assumed.)

In this example, the interference from PDC-FWA to PDC conditions is calculated on the assumption that the conditions from PDC-FWA to PDC and the conditions from PDC to PDC-FWA are symmetrical in radio path design.

1 Calculating the necessary propagation loss

System parameters for FWA and MWA assumed systems are given in Table 2.

TABLE 2

Assumed system (FWA user station and MWA base station)

a) FWA user station

Parameter	Contents
Interface	R1
System	PDC-FWA
Access/duplex method	TDMA/FDD
Number of slots	3
Transmit power, P_{tS}	30 dBm (peak)
Bandwidth	50 kHz
Antenna gain, G_S	13 dBi (directional)
Feeder loss, L_{fS}	1 dB
Height of feeder point, h_S	10 m

b) MWA base station

Parameter	Contents
Interface	R1
System	PDC
Access/duplex method	TDMA/FDD
Number of slots	3
Bandwidth	50 kHz
Noise figure	7 dB
Noise floor	–120 dBm
Antenna gain, G_B	11 dBi (omnidirectional)
Feeder loss, L_{fB}	2 dB (50 m feeder)
Height of feeder point, h_B	50 m
Allowable I/N ratio	X dB

The necessary propagation loss for the system assumed in Table 2 will be as follows:

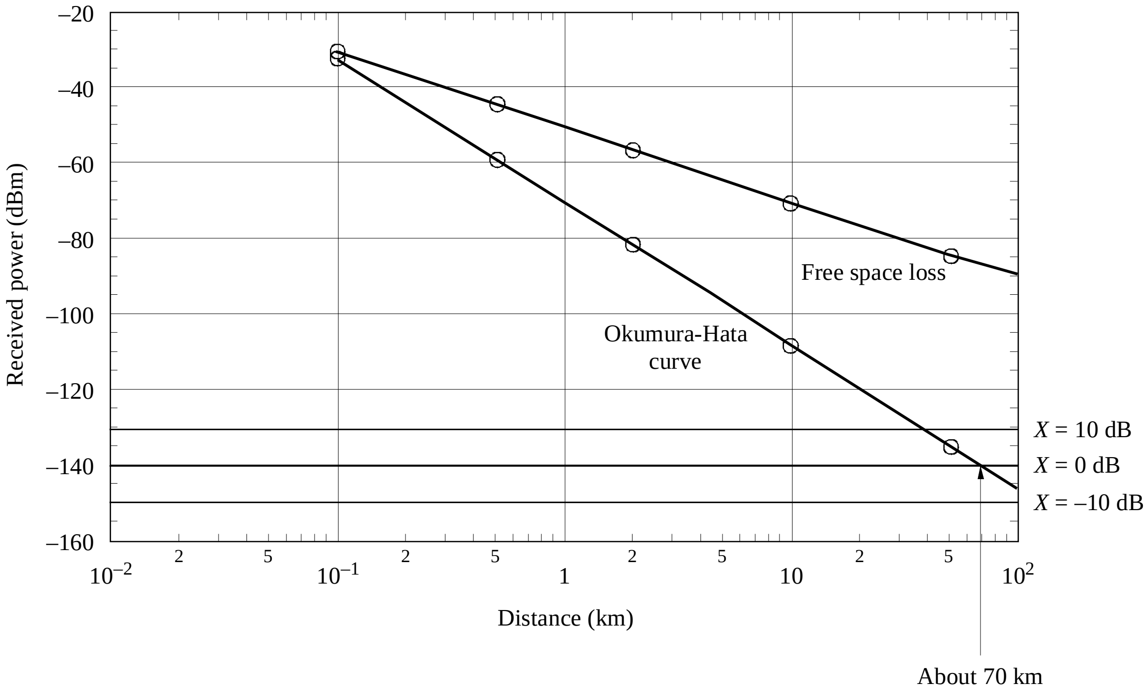
$$\begin{aligned} L(d_{min}) &= P_{tS} - L_{fS} - L_{fB} + G_S + G_B - (N_B + X) \\ &= 30 - 1 - 2 + 13 + 11 - (-120 + X) \\ &= 171 - X \quad \text{dB} \end{aligned} \tag{9}$$

2 Calculating the separation distance

In Fig. 5, the separation distance is calculated using Okumura-Hata curve. The separation distance will be about 70 km at X = 0 dB.

FIGURE 5

Calculation of separation distance



Note 1 – Adjustment based on the topographical and building conditions is not considered.

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