ARIB STD－T59

FIXED WIRELESS ACCESS SYSTEM USING QUASI-MILLIMETER-WAVE- AND MILLIMETER-WAVE-BAND FREQUENCIES POINT-TO-MULTIPOINT SYSTEM

ARIB STANDARD

VERSION 1 REV.-1

ARIB STD－T59

Version 1	March	30th	1999
Version 1 Rev.-1	March	29th	2000

Association of Radio Industries and Businesses (ARIB)

General notes for the English version of the ARIB Standard T59

The original "FIXED WIRELESS ACCESS SYSTEM USING QUASI-MILLIMETER-WAVE- AND MILLIMETER-WAVE-BAND FREQUENCIES POINT-TO-MULTIPOINT SYSTEM (ARIB STD-T59)" is written in Japanese and has been approved (Version 1 Rev.-1 release on March 29, 2000). This document is the translation of the Standard into English. In case of dispute, the Japanese text shall prevail.

Introduction

With the participation of radio equipment manufacturers, telecommunications operators, and users, ARIB (Association of Radio Industries and Businesses) has established basic technical specifications of radio equipment as "Technical Standards" for all types of systems using radio waves.

These Standards are private industry standards that incorporate both government regulations(Note) prescribed for effective use of frequencies and avoidance of interference with other users, and arbitrary private standards established to achieve quality in radio equipment, to guarantee compatibility, and to ensure convenience for radio equipment manufacturers, telecommunications operators, and users.

This Standard has been established for "Point-to-multipoint fixed wireless access system using quasi-millimeter-wave- and millimeter-wave-band frequencies." To ensure fairness and transparency in the establishment stage, all interested parties including Japanese and foreign radio equipment manufacturers, telecommunications operators, and users were asked to participate in reaching a general consensus at "The Standard Assembly" held by ARIB.

Considering the present situation of the current network systems and technical developments relating to quasi-millimeter and millimeter waves, this Standard prescribes the minimum requirements for the construction of local access links consist of "Point-to-multipoint fixed wireless access system using quasi-millimeter-wave- and millimeter-wave-band frequencies. "

Therefore, it is required that telecommunications operators keep the requirements stipulated in this Standard for constructions of such systems. In addition, considering the development of new radio technology and the evolution of the manufacturing technology it will be needed to use each operator’s own established rules and standard values under this Standard.

ARIB hopes that this Standard will be actively used by radio equipment manufacturers, telecommunications operators and users. Moreover, ARIB also hopes that this Standard will be improved under the technological innovation and the "Fixed wireless access system" will be developed and become widespread more in the future.

Note: Technical Requirement stipulated in Japanese Radio Law, related ministerial ordinances and Regulations

Table of Contents

Chapter 1 Scope

1.1 Overview

This Standard applies to the point-to-multipoint radio equipment (hereinafter referred to as "P-MP system") among the radio stations for subscriber radio access communications as defined in Item 25, Clause 7 of the Radio Equipment Regulation.

1.2 Scope of Application

As shown in Figure 1.1, the P-MP system consists of radio transmission paths that link a base station installed by a telecommunications operator and subscriber stations.
This Standard prescribes conditions to be met by transmitter, receiver and antenna used in both the base stations and subscriber stations when the system is operating. Monitoring and controlling functions are included in the transmitter and receiver.

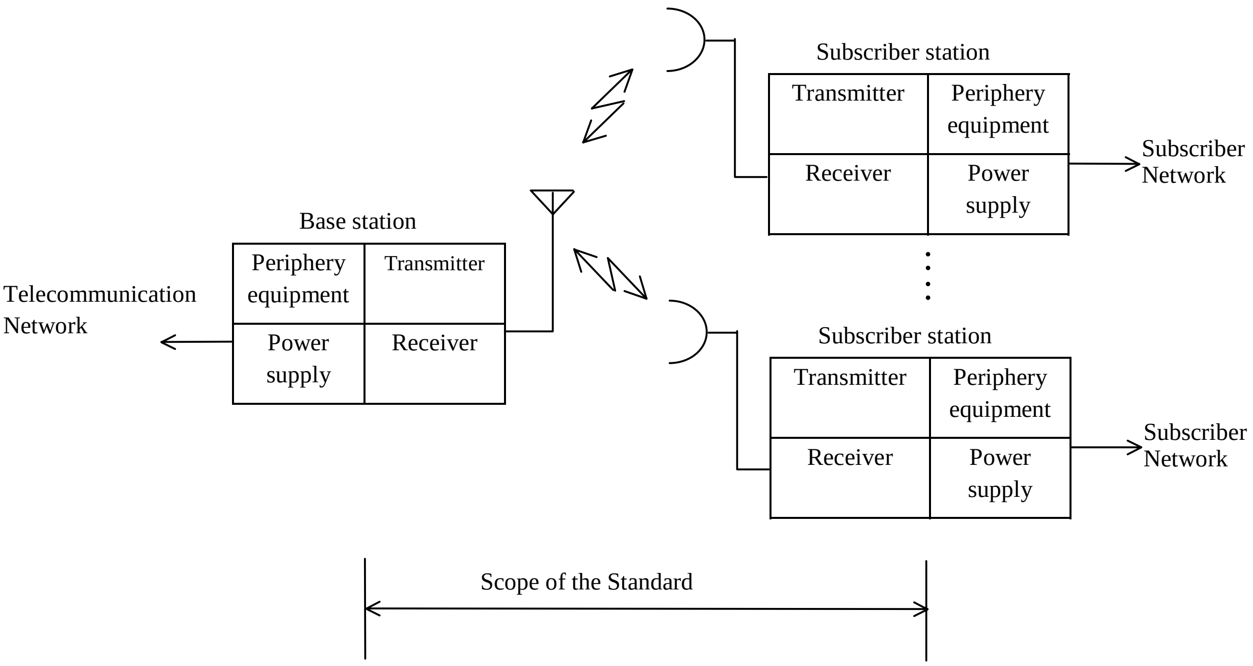


Figure 1.1 P-MP system configuration

1.3 Conforming Documents

The terms used in this standard is as defined by the Radio Law and related ministerial ordinances unless otherwise stated.
In this standard, the "Equipment Regulation" refers to the Radio Equipment Regulation and "Public Notice" refers to a public notice issued by Ministry of Posts and Telecommunications. In further instances, the Radio Law and related ministerial ordinances may be quoted with partial abbreviation in this standard. However, where interpretation is unclear, refer to the Radio Law and ministerial ordinances themselves.

Chapter 2 Technical Requirements for Radio Equipment

2.1 General

(1) Frequency bands (Equipment Regulation: Clause 49.19)

Frequencies of more than or equal to 25.25 GHz and less than or equal to 27 GHz, more than or equal to 38.05 GHz and less than or equal to 38.5 GHz, more than or equal to 39.05 GHz and less than or equal to 39.5 GHz shall be used.

(2) Communication system (Equipment Regulation: Clause 49.19)

a. Base station

The base station shall be a Frequency Division Duplex system (FDD) or a Time Division Duplex system (TDD) that uses a Frequency Division Multiplex system (FDM) or a Time Division Multiplex system (TDM).

b. Subscriber station

The subscriber station shall be an FDD or a TDD that uses Frequency Division Multiple Access system (FDMA) or a Time Division Multiple Access system (TDMA).

(3) Modulation method

Modulation method shall be GMSK, Quadrature Phase Shift Keying (including π/4-shift QPSK, DQPSK, OQPSK) or 16-level, 32-level or 64-level Quadrature Amplitude Modulation.

(4) Transmitter power (Equipment Regulation: Clause 49.19)

Transmitter power is the power supplied to the feeder line of the antenna system. The value shall be as shown in Table 2.1. Note that the transmitter power may be controllable.

Table 2.1 Transmitter power

Transmitter power	500 mW or less

(5) Transmitter power spectral density

Transmitter power spectral density is the transmitter power divided by the occupied bandwidth. The value shall be as shown in Table 2.2.

Table 2.2 Transmitter power spectral density

Transmitter power spectral density	19 dBm/MHz or less

(6) Radio wave polarization (Equipment Regulation: Clause 49.19)

The polarization of the transmitting or receiving radio wave shall be horizontal or vertical polarization.

(7) Transmitter antenna characteristics (Equipment Regulation: Clause 49.19)

Base station: No requirements in particular, but shall have characteristics to enable sufficient coverage of service area.

Subscriber station: Shall be a directional antenna with the absolute gain of 20 dBi or higher.

2.2 Transmitter

(1) Permissible frequency tolerance (Equipment Regulation: Clause 5)

The tolerance shall be as shown in Table 2.3.

Table 2.3 Permissible frequency tolerance

Permissible frequency tolerance	$\pm 1.5 \times 10^{-5}$

(2) Permissible occupied bandwidth (Equipment Regulation: Clause 6)

The Permissible value of the bandwidth occupied by the emitted radio wave shall be as calculated by using the formula for each modulation method shown in Table 2.4. Note, however, that a fraction of less than 500 kHz is rounded up to 500 kHz and that a fraction of more than 500 kHz but less than 1 MHz is rounded up to 1 MHz.

Table 2.4 Permissible occupied bandwidth (Public Notice No. 604, 1998)

Modulation method	Permissible occupied bandwidth in the form of the calculating formula
Quadrature Phase Shift Keying	Clock frequency [MHz] × (1+α) α: the roll-off rate (The roll-off rate shall be 0.5 or less.)
16-level Quadrature Amplitude Modulation 32-level Quadrature Amplitude Modulation 64-level Quadrature Amplitude Modulation	Clock frequency [MHz] × 1.3 (The roll-off rate shall be 0.5 or less.)
GMSK	Clock frequency [MHz] × 1.0 (In the case that the normalized 3 dB bandwidth (one-side) of the Gaussian low-pass filter is 0.25) Clock frequency [MHz] × 1.2 (In the case that the normalized 3 dB bandwidth (one-side) of the Gaussian low-pass filter is 0.5)

(3) Permissible spurious emission (Equipment Regulation: Clause 7)

The permissible spurious emission is shown in Table 2.5, where spurious emission is defined as an average power value for each frequency supplied to the feeder line.

Table 2.5 Permissible spurious emission

Permissible spurious emission	50 μW or less

(4) Permissible deviation of transmitter power

Permissible deviation of transmitter power is shown in Table 2.6.

Table 2.6 Permissible deviation of transmitter power

Maximum	Minimum
Nominal Power +50 %	Nominal Power –50 %

Where the transmitter power control function exists, the minimum value is not applied when the power is reduced, while maximum value shall be applied using maximum power of the nominal variable range as nominal power.

(5) Transmission spectral mask

The transmission spectral mask for a TDMA system is prescribed in Figure 2.1 and that for an FDMA system in Figure 2.2. When a transmitter sends multiple carriers, this spectral mask shall be satisfied in the situation where all carriers are being sent.

Here, BW is a frequency separation defined by Fig.2.1 and Fig. 2.2.

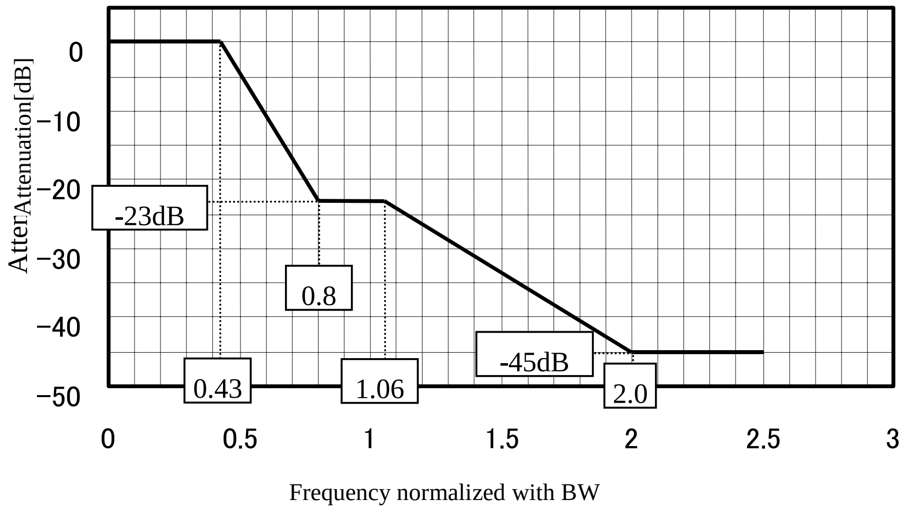


Figure 2.1 TDMA spectral mask

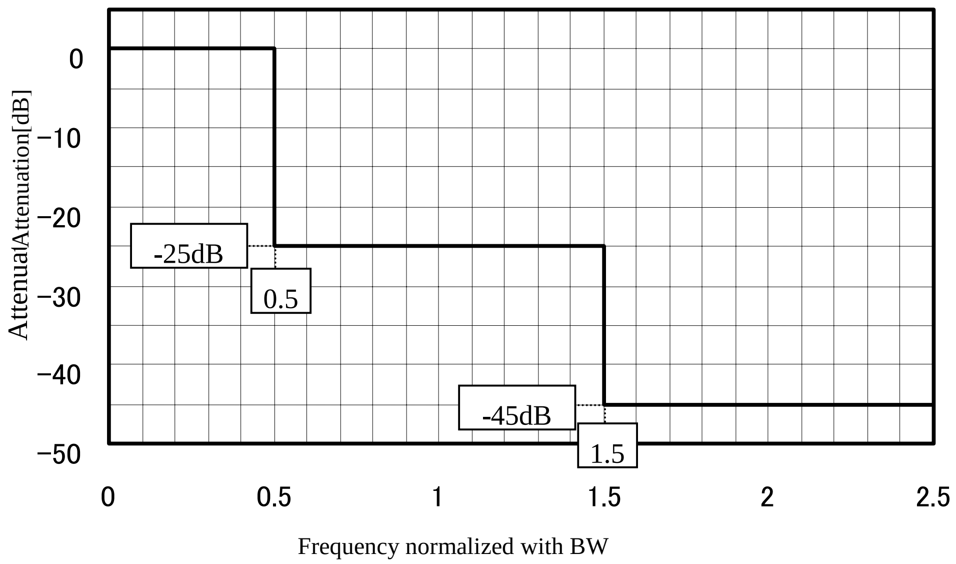


Figure 2.2 FDMA spectral mask

(6) Carrier separation from boundary frequency

The carrier separation from boundary frequency is the difference between the center frequency of a carrier and the boundary frequency, where the boundary frequency is defined as the frequency of the boundary between the frequency block allocated to Operator-A and the adjacent frequency block allocated to Operator-B to avoid the interference to operator-B (or operator-A). The carrier separation from boundary frequency shall be equal to or more than the value shown in Figure 2.3 including the permissible frequency tolerance.

$$\text{Minimum Carrier separation from boundary frequency} = \text{Permissible frequency tolerance} + \frac{\text{Permissible occupied bandwidth}}{2}$$

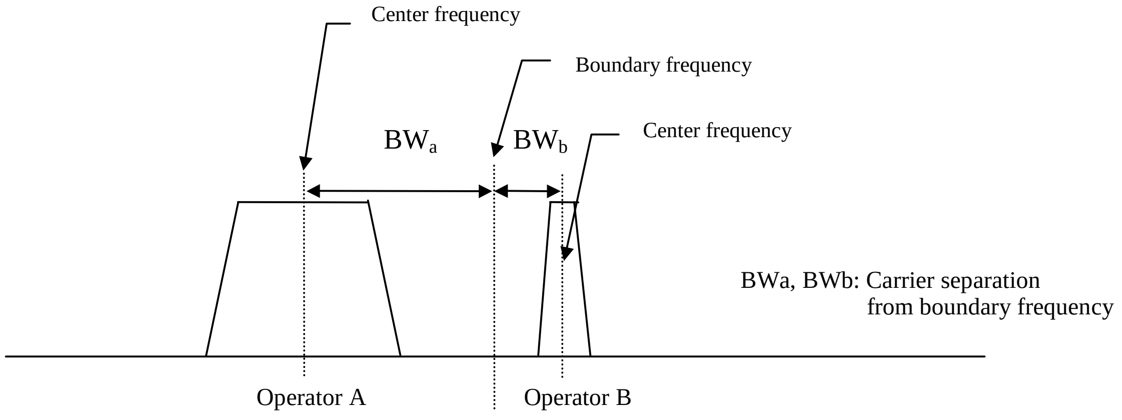


Figure 2.3 Figure showing concept of Carrier separation from boundary frequency

In addition to the condition given in the above formula, this Standard calls for a requirement that Carrier separation from boundary frequency shall be at least 1 BW, where the BW is defined in 2.2(5).
Note that when the center frequency is less than 1 BW apart from the boundary frequency, the power leakage to the adjacent frequency block shall satisfy the limit given in 2.2(7).

(7) Power leakage to adjacent frequency block

The power leakage to the adjacent frequency block is defined as the EIRP value at the separation point divided by the occupied bandwidth. The value shall be as shown in Table 2.7.

Table 2.7 Power leakage to the adjacent frequency block

The own-system	Separation from boundary frequency (*1)	Leakage power to the adjacent frequency block (EIRP: dBm/MHz) (*2)
TDMA	0 BW	A - 23
	1 BW	A - 45
FDMA	0 BW	A - 25
	0.5 BW	A - 45

*1: The unit shall be the BW of the own system.
*2: The value A shall be obtained from Table 2.8, and lower value shall be selected.

Table 2.8　Value of A in Table 2.7

Item	Value of A
Base station	30
	38 - B
Subscriber station	49
	57 - B

Table 2.9　Value of B in Table 2.8

The own system	Value of B
Single carrier system	$10 \log_{10}$ (occupied bandwidth [MHz])
Multi-carrier system	$10 \log_{10}$ (occupied bandwidth [MHz] × number of carriers)

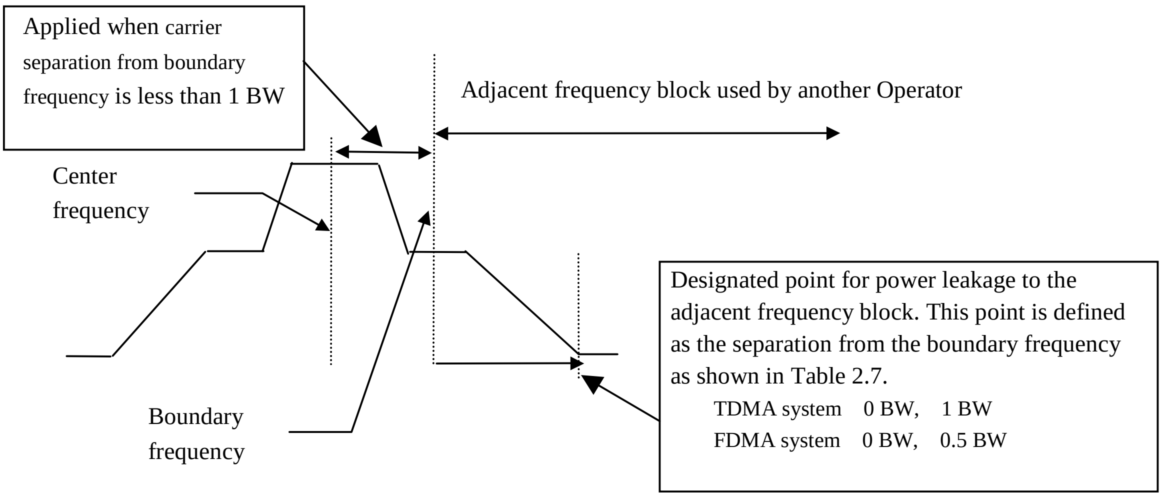


Figure 2.4　Conceptual diagram showing designated point for power leakage to the adjacent frequency block

2.3　Receiver

(1)　Limitation to subsidiary emitted radio waves　(Equipment Regulation: Clause 24)

Subsidiary emitted radio waves from receiver, shall satisfy the requirements in Table 2.10 not to impede the functions of other radio equipment.

Table 2.10　Limitation to subsidiary emitted radio waves

Frequency	Limitation to subsidiary emitted radio waves
Lower than 1 GHz	4 nW or less
1 GHz or higher	20 nW or less

2.4 Others

(1) Monitoring and controlling function

a. The system shall have the monitoring and controlling functions required for system operation and maintenance.

b. Auxiliary signals for monitoring and control shall be transmitted using time-division within the main radio signal and shall not be transmitted using a special carrier or modulation.

Chapter 3 Measurement Methods

3.1 General

3.1.1 Measurement Items

(1) Frequency tolerance
(2) Occupied bandwidth
(3) Spurious emission
(4) Deviation of transmitter power
(5) Subsidiary emitted radio waves from receiver
(6) Transmission spectral mask

3.1.2 Common conditions

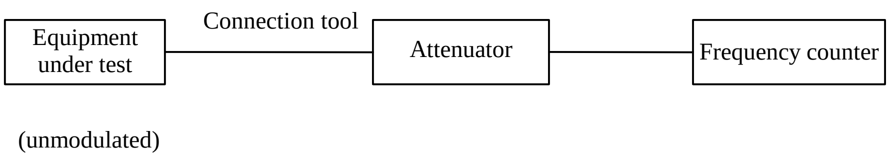
(1) Standard code sequence test signal: 15-stage PN code in conformity with Recommendation ITU-T O.151.

(2) Forced transmission control: The function to make forced control during any required time to keep continuous transmission status for the system that uses continuous transmission mode and to keep continual burst transmission status for the system that uses burst transmission mode.

(3) Measurement monitor terminal: Terminal to obtain an output signal having identical characteristics as the main signal for relevant measurement item. The measurement at this terminal shall not affect the main signal during the measurement supplying appropriate signal output required for the measuring equipment.

3.2 Frequency Tolerance

3.2.1 Diagram of measurement system



The connection tool may be any type of wave-guide (WG) transducer.

3.2.2 Measuring equipment conditions

(1) Where necessary, a coaxial/wave-guide transducer may be used.
(2) A frequency counter or a spectrum analyzer may be used as the frequency counter.
(3) The precision of the frequency counter shall be ten times or more precise than the required permissible frequency tolerance.

3.2.3 Conditions of equipment under test

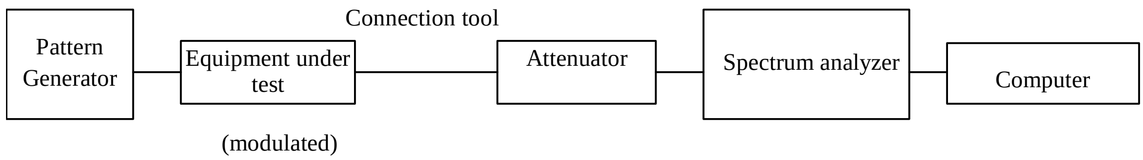
(1) Transmission shall be made after setting the designated channel. In equipment that transmits multiple carriers, the measurement shall be made at each designated channel.
(2) As a rule, unmodulated signal is applied.
(3) Measurement shall be made at the antenna terminal or the measurement monitor terminal. In the case that these terminals can not be used for measurement, measurement shall be made using an appropriate RF coupler or an antenna.

3.2.4 Measurement procedure

(1) The frequency of the equipment under test is measured several times after pre-heating until being stabilized. Note however, that just one measurement is sufficient if the equipment under test has high frequency stability immediately after warming-up.

3.3 Occupied Bandwidth

3.3.1 The measurement system



The connection tool may be any type of wave-guide (WG) transducer.

3.3.2 Measuring equipment conditions

(1) Spectrum analyzer settings shall be as follows when measuring continuous waves.

Center frequency:	Carrier frequency
Sweep bandwidth:	Two to three times or more than the permissible occupied bandwidth
Resolution bandwidth:	Approximately 3 % or less of the permissible occupied bandwidth
Video bandwidth:	Same as resolution bandwidth
Y scale:	10 dB/Div
Input level:	The carrier wave level shall be 50 dB or more than the spectrum analyzer noise level.
Data points:	400 or more
Average amplitude processing:	Between 5 and 10 times
Detection mode:	Sample

(2) Spectrum analyzer settings shall be as follows when measuring burst waves.

Center frequency:	Carrier frequency
Sweep bandwidth:	Two to three times or more than the permissible occupied bandwidth
Resolution bandwidth:	Approximately 3 % or less of the permissible occupied bandwidth
Video bandwidth:	Same as resolution bandwidth
Y scale:	10 dB/Div
Input level:	The carrier wave level shall be 50 dB or more than the spectrum analyzer noise level.
Data points:	400 or more
Sweep time:	There shall be at least one burst per sample

Sweep mode: There shall be a single sweep during continual burst transmission at a constant cycle.

Detection mode: Positive peak

(3) The measured spectrum analyzer data are processed by an external or internal computer.

(4) The pattern generator shall be the signal source that generates the standard code sequence test signal at the prescribed transmission speed. The standard code sequence test signal shall be a signal where randomness is maintained. (A built-in pattern generator may be used.)

3.3.3 Conditions of equipment under test

(1) Transmission shall be made after setting the test frequency and under forced transmission control. In equipment that transmits multiple carriers, the measurement shall be made at each designated channel.

(2) Modulation shall be made using the standard code sequence test signal.

(3) When error correction is used, the error correction signal shall be applied.

(4) Measurement shall be made at the antenna terminal or the measurement monitor terminal. In the case that these terminals can not be used for measurement, measurement shall be made using an appropriate RF coupler or an antenna.

3.3.4 Measurement procedure

(1) Averaging operation

When measuring continuous waves, multiple sweeps of the spectrum analyzer are made to determine the average amplitude of same data points.

(2) Fetching data

When measuring continuous waves, values of all data points are fetched into array variables after repeating the necessary number of sweeps. When measuring burst waves, values of all data points are fetched into arrayed variables after completing one sweep.

(3) Antilogarithm conversion

All data in the dBm value are converted into the antilogarithm values in power dimension (They may be relative values).

(4) Calculation of the total power

The total power is calculated using all data and this is recorded as "total power".

(5) Calculation of the lower threshold frequency

The power value is summed up in up-ward sequence starting from the minimum frequency data. When this value becomes equal to 0.5% of the total power, the last data point is recorded as the threshold point. Frequency corresponding this data point is recorded as the "lower threshold frequency".

(6) Calculation of the upper threshold frequency

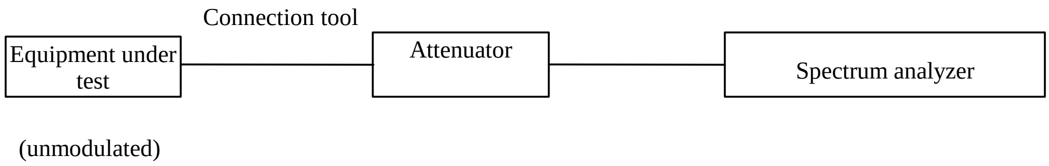
The power value is summed up in downward sequence starting from the maximum frequency data. When this value becomes equal to 0.5% of the total power, the last data point is recorded as the threshold point. Frequency corresponding this data point is recorded as the "upper threshold frequency".

(7) Calculation of the occupied bandwidth

The occupied bandwidth is calculated as ("upper threshold frequency" - "lower threshold frequency").

3.4 Spurious Emission

3.4.1 The measurement system



The connection tool may be any type of wave-guide (WG) transducer.

3.4.2 Measurement equipment conditions

(1) An attenuator having an applicable frequency range of twice or more than the allocated frequency is appropriate.
(2) When the second higher harmonic wave is to be measured, input level of the fundamental wave is set to be low so that no internal higher harmonic wave is produced in the spectrum analyzer.
(3) The resolution bandwidth of the spectrum analyzer shall be between 10 and 30 kHz, in consideration of both measurement accuracy and reduction of required measurement time.
(4) When measuring burst waves, the sweep time shall be equal to or more than

$$\frac{\text{sweep frequency width}}{\text{resolution bandwidth}} \times \text{burst cycle}$$

3.4.3 Conditions of equipment under test

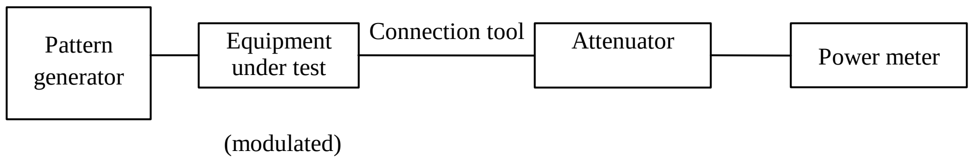
(1) Transmission shall be made after setting the test frequency and under forced transmission control. In equipment that transmits multiple carriers, the measurement shall be made at each designated channel.
(2) Measurement shall be made at the antenna connection flange. In the case of equipment for which the connection tool cannot be connected to the antenna connection flange for measurement, measurement shall be made in a radio dark room or at an open site with suppression of earth-reflected radio waves, or alternatively by using an appropriate coupler which has been calibrated at such a test site. In this case, the substitution method shall be used with other conditions being kept same as above. The antenna for substitution measurement at the test site shall be a directional antenna.

3.4.4 Measurement procedure

(1) The measurement frequency of the spectrum analyzer is swept from the cut-off frequency for the wave-guide of the equipment under test to the second higher harmonic wave frequency. The amplitude of the fundamental wave is measured and spurious emissions detective operation must be executed.
(2) If required, the amplitudes of the detected spurious emissions are re-measured. In this case, the sweep width of the spectrum analyzer is set to a necessary minimum.

3.5 Deviation of Transmitter Power

3.5.1 The measurement system



The connection tool may be any type of wave-guide (WG) transducer.

3.5.2 Measuring equipment conditions

(1) The most appropriate operating input to the power meter shall be given by setting the attenuator. The power meter for measuring the equipment which transmits burst waves shall have a time constant that is much longer than the burst cycle.

3.5.3 Conditions of equipment under test

(1) The equipment under test is set to transmit at the designated channel in the modulated state. The burst transmission equipment is set to the burst transmission state. In equipment that transmits multiple carriers, the measurement shall be made at each designated channel.

(2) Measurement shall be made at the antenna connection flange. In the case of equipment for which the connection tool cannot be connected to the antenna connection flange for measurement, measurement shall be made in a radio dark room or at an open site with suppression of earth-reflected radio waves, or alternatively by using an appropriate coupler which has been calibrated at such a test site. In this case, the substitution method shall be used with other conditions being kept same as above. The antenna for substitution measurement at the test site shall be a directional antenna.

3.5.4 Measurement procedure

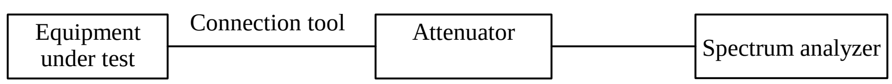
(1) The power meter is calibrated at zero power.

(2) Transmission is made.

(3) The average power is measured.
When measuring power of equipment for burst transmission, the average power within a burst is calculated by dividing the measured power value by the transmission duty ratio.

3.6 Subsidiary Emitted Radio Waves from Receiver

3.6.1 The measurement system



The connection tool may be any wave-guide (WG) transducer.

3.6.2 Measuring equipment conditions

(1) Set the spectrum analyzer as follows:

Sweep bandwidth:	Stated in Item 3.6.4, "Measurement procedure".
Resolution bandwidth:	Value determined by the required dynamic range (from internal noise level to saturation level) and the sweep time.
Video bandwidth:	Same as resolution bandwidth
Y axis scale:	10 dB/Div
Input attenuator:	0 dB (as far as possible)

3.6.3 Conditions of the equipment under test

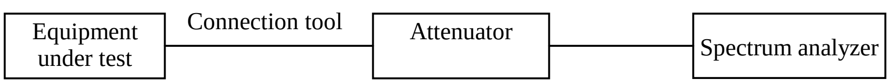
(1) The equipment is set to the designated channel.
(2) Transmission is ceased and the equipment is placed in the receiving mode.
(3) Measurement shall be made at the antenna connection flange. In the case of equipment for which the connection tool cannot be connected to the antenna connection flange for measurement, measurement shall be made in a radio dark room or at an open site with suppression of earth-reflected radio waves, or alternatively by using an appropriate coupler which has been calibrated at such a test site. In this case, the substitution method shall be used with other conditions being kept same as above. The antenna for substitution measurement at the test site shall be a directional antenna.

3.6.4 Measurement procedure

(1) The spectrum analyzer is set to sweep its frequency from the lowest possible frequency through to a frequency about twice that of the carrier wave. Note, however, that the sweep width for the wave-guide element incorporated equipment will be determined upon consideration of the frequency characteristics of the wave-guide and the measurement equipment (the external mixer, for example). In the case of the wave-guide element incorporated equipment, measurement may be omitted if there clearly is no secondary emission in lower bands.
(2) The spectrum analyzer is calibrated in advance and the secondary emission power is calculated on the basis of the ratio to the measured reference power.

3.7 Transmission spectral mask

3.7.1 The measurement system



The connection tool may be any wave-guide (WG) transducer.

3.7.2 Measuring equipment conditions

(1) The spectrum analyzer shall be set as follows.

Center frequency:	Carrier wave frequency
Sweep frequency bandwidth:	5.7 times channel spacing or more
Sweep time:	Automatic
Resolution bandwidth:	30 kHz for channel spacing of 14 MHz or less
	100 kHz for channel spacing of more than 14 MHz up to 60MHz
Video bandwidth:	0.1 kHz for TDMA channel spacing of 3.5 MHz or less

	0.3 kHz for FDMA channel spacing of 3.5 MHz or less
	0.3 kHz for channel spacing of more than 3.5 MHz up to 60 MHz
Y scale:	10 dB/Div
Input level:	The carrier level shall be at least 50 dB higher than the spectrum analyzer noise level

3.7.3 Conditions of equipment under test

(1) Transmission shall be made after setting the test frequency and under forced transmission control. In equipment that transmits multiple carriers, the measurement shall be made at each designated channel.

(2) Modulation shall be made using the standard code sequence test signal.

(3) When error correction is included, error correction shall be applied to obtain actual test spectrum.

(4) Measurement shall be made at the antenna terminal or the measurement monitor terminal. In the case that these terminals can not be used for measurement, measurement shall be made using an appropriate RF coupler or an antenna.

3.7.4 Measurement procedure

(1) The spectral mask is measured. The maximum measured value is regarded as 0 dB.

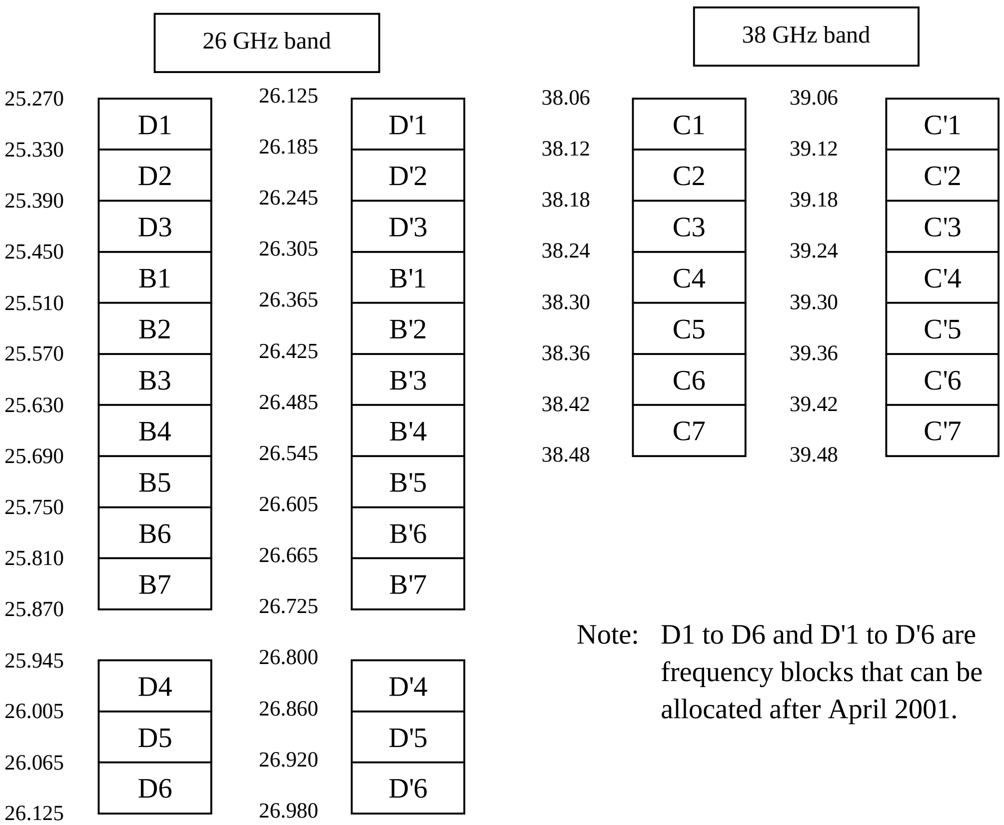
Appendix

Appendix-1 Basic Concepts for the P-MP System

In setting this standard, reference has been made to the "Basic guideline for the introduction of a new Fixed wireless access system using quasi-millimeter-wave- and millimeter-wave-band frequencies. " and "Guideline for radio station licenses for a new Fixed wireless access system using quasi-millimeter-wave- and millimeter-wave-band frequencies. " (December 24, 1998).
The basic concepts in these references are given below.

(1) Segmentation of frequency bands into blocks
In the P-MP system, the frequency bands used are segmented into frequency blocks of a frequency bandwidth of 60 MHz at each base station transmission and subscriber station transmission (total of 120 MHz).

(2) Basic concept for frequency of base station and subscriber station
- A In FDD, the base station uses a upper band and the subscriber station uses a lower band. In TDD, both stations use either or both bands. Figure A-1.1 shows the frequency blocks.
- B No guard band can be set between frequency blocks.



Note: D1 to D6 and D'1 to D'6 are frequency blocks that can be allocated after April 2001.

Figure A-1.1 Frequency blocks

(3) Basic concepts concerning avoidance of interference and others

In using the frequency of 26 GHz, measures to avoid interference to/from inter-satellites communications system and geostationary satellite communications system shall be considered.

(4) Transmission speed

Unless the designated frequency bandwidth exceeds bandwidth of a block (60 MHz) and system causes significant affects such as interference to other stations, the maximum transmission speed of P-MP system shall not be prescribed.

Appendix-2 Basic Concepts Relating to Protection from Interference

Technical requirements have been established to provide protection against interference when different operators use adjacent frequency blocks.
The basic concepts behind these requirements and relevant items are given below.

1. Prerequisites for protection from interference

(1) The standard cell radius shall be 1 km.
(2) The subscriber station shall not cause harmful interference with a different operator's base station at a distance of approximately 1 km or more.
(3) The base station shall not cause harmful interference with a different operator's subscriber station at a distance of approximately 1 km or more.

2. Technical requirements for protection from interference

To satisfy the "Prerequisites for protection from interference," the technical requirements have been established for the following items.

(1) Transmitter power spectral density	(refer to Item 2.1 (5) in Chapter 2)
(2) Transmission spectral mask	(refer to Item 2.2 (5) in Chapter 2)
(3) Carrier separation from boundary frequency	(refer to Item 2.2 (6) in Chapter 2)
(4) Power leakage to adjacent frequency block	(refer to Item 2.2 (7) in Chapter 2)

Appendix-3 gives an example of radio link design.

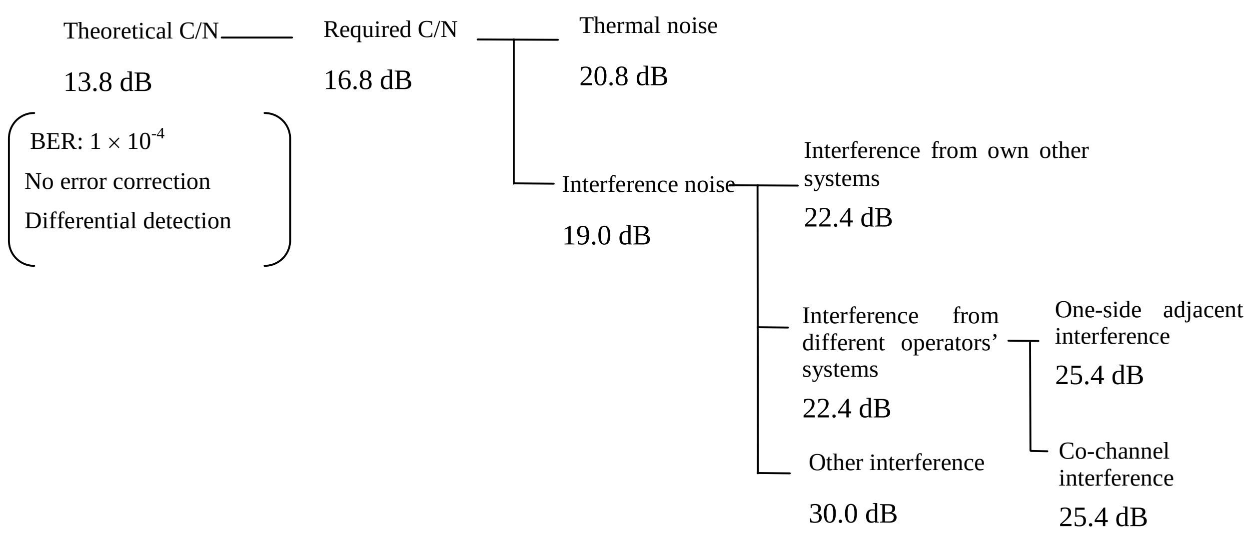
Appendix-3　Example of Radio Link Design

An example of noise budget is given in Table A-3.1 and an example of radio link design based on the following conditions is given in Table A-3.2.

Modulation method	QPSK
Link unavailability caused by rainfall	0.004 %/year
Rainfall intensity at 0.0075% on cumulative probability distribution of rainfall per minute	1.66 mm/min (Tokyo)
Path length	1 km
Noise bandwidth	16 MHz

Table A-3.1 Example for noise budget

(a) Up link



(b) Down link

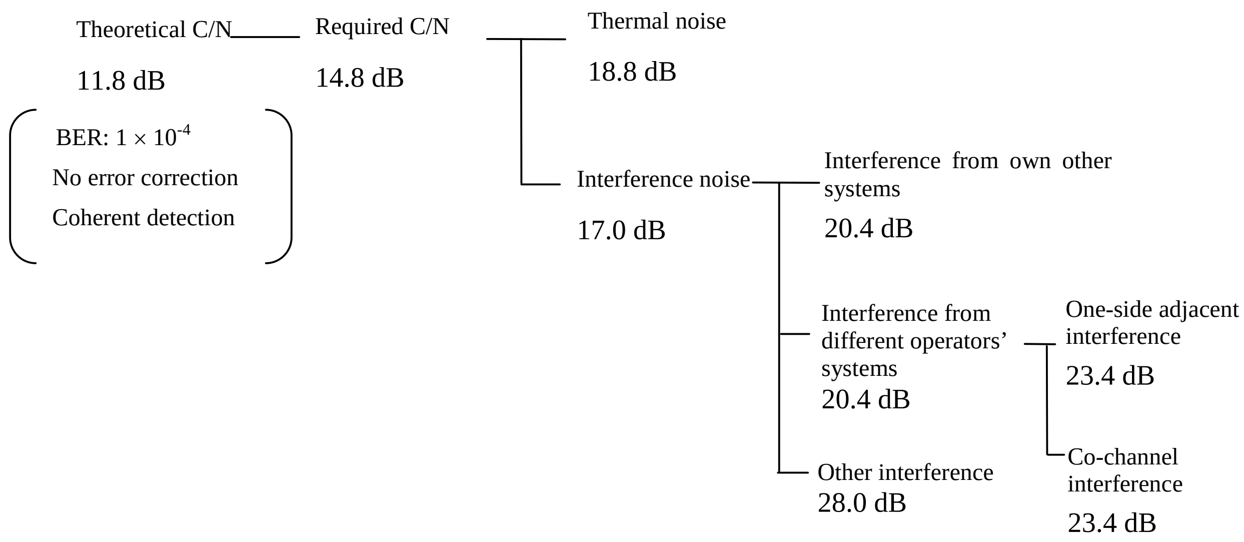


Table A-3.2 Example of radio link budget

	Down link	Up link
(1) Radio frequency [GHz]	26.125	
(2) Transmitter power [dBm]	22.0	
(3) Transmitter antenna gain [dBi]	16.0	33.0
(4) Free space propagation loss [dB]	120.8	
(5) Tilt loss [dB]	6.8	
(6) Receiver antenna gain [dBi]	33.0	16.0
(7) Feeder loss in transmission and reception systems [dB]	2.0	
(8) Receiver input level (clear air) [dBm]	-58.6	
(9) Receiver thermal noise [dBm]	-93.8	-95
(10) Receiver noise figure [dB]	8.0	7.0
(11) Rainfall loss [dB]	13.3	
(12) Fixed deterioration from theoretical value [dB]	3.0	
(13) Thermal noise C/N allocated [dB]	18.8	20.8
(14) Thermal noise allocation rate in required C/N [%]	40.0	
(15) Thermal noise C/N at rainfall reduction [dB]	21.9	23.1
(16) Margin (15) - (13) [dB]	3.1	2.3

Appendix-4 Basis for value A in Table 2.8 and value B in Table 2.9

Value A in Table 2.8 and value B in Table 2.9 are estimated almost according to the model assumed for the example of radio link design in Appendix-3. A specification of the model is shown in Table A-4.1.
Value A and value B are obtained considering this model and specified maximum power density (in Chapter 2) as following.

(1) Value A: the EIRP value

Value A of base station

= Specified maximum transmitter power density
- Feeder loss (2 dB) + Antenna gain (16 dBi) - 3 dB

Value A of subscriber station

= Specified maximum transmitter power density
- Feeder loss (0 dB) + Antenna gain (33 dBi) - 3 dB

Specified maximum transmitter power density [dBm/MHz] =

- 19 (Specified transmitter power spectral density in Table 2.2)
- 27 - B (Convert from specified transmitter power in Table 2.1 to transmitter power spectral density)

(The smaller value shall be used for satisfaction of both conditions.)

Value B: Total occupied bandwidth of transmitted carrier

B =

- $10\log_{10}$ (Occupied bandwidth [MHz]) Single carrier system
- $10\log_{10}$ (Occupied bandwidth [MHz] $\times$ number of carriers) Multi carrier system

Table A-4.1 Standard model specification

(a) Base station specification

Item	Specification
Modulation method	QPSK
Antenna gain	16 dBi
Feeder loss	2 dB
Transmitter power	22 dBm
Receiver input level (clear air)	-58.6 dBm
Symbol rate	16 Msymbol/sec
Receiving filter	Equal split square root 50 % roll-off filter
Channel spacing	24.0 MHz

(b) Subscriber station specification

Item	Specification
Modulation method	QPSK
Antenna gain	33 dBi
Feeder loss	0 dB
Transmitter power	22 dBm
Receiver input level (clear air)	-58.6 dBm
Symbol rate	16 Msymbol/sec
Receiving filter	Equal split square root 50 % roll-off filter
Channel spacing	24.0 MHz

Note 1) Channel spacing = 1.5 × Symbol rate
Occupied bandwidth = 1.278 × Symbol rate

Appendix-5 Conditions for Coexistence of TDD System and FDD System

Possible interference paths in case of adjacent block collocation of TDD system and FDD system depend on whether TDD system is allocated to upper band or lower band as shown in Figure A-5.1. There are eight possible cases as follows.

TDD system frequency allocation	Interference cases		
Upper band	(1) FDD base station	→	TDD base station
	(2) FDD base station	→	TDD subscriber station
	(3) TDD base station	→	FDD subscriber station
	(4) TDD subscriber station	→	FDD subscriber station
Lower band	(5) FDD subscriber station	→	TDD base station
	(6) FDD subscriber station	→	TDD subscriber station
	(7) TDD base station	→	FDD base station
	(8) TDD subscriber station	→	FDD base station

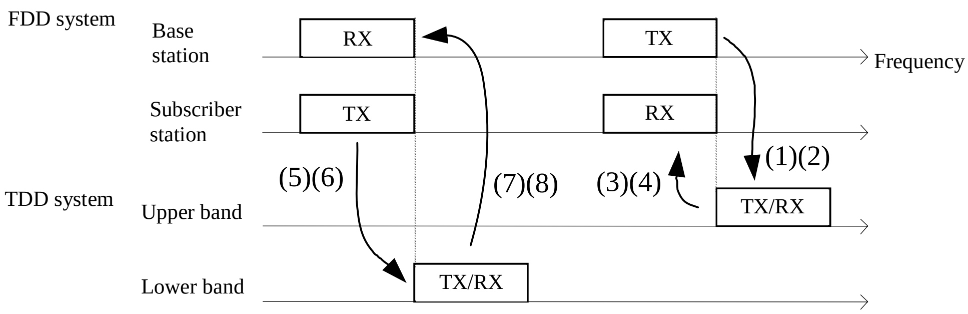


Figure A-5.1 Coexistence of TDD system and FDD system

Case (1) and (7) are possible interference models among FDD and TDD base stations where TDD system is allocated to upper band and lower band, respectively and except for these cases, possible coexistence distance of 1 km shall be applied as well as the FDD-to-FDD interference model.

In cases of (1) and (7), by low gain of base station antenna in contrast to subscriber antenna, the coexistence distance can be reduced (to less than 1 km). Assuming the TDD system specification same as the specification of an "Example of radio link design" of Appendix-3, the distance between base stations can be 140 m (free space propagation loss = 103.8 dB) by 17dB reduction of required propagation loss (subscriber station antenna gain 33 dBi - base station antenna gain 16 dBi). Moreover, closer collocation will be possible by taking account of base station antenna's directivity when using sector antennas or other antennas.

Appendix-6 Conditions for Coexistence of P-MP System and P-P System

Study result of conditions for coexistence of P-MP system and P-P system is shown below.

(1) Interference from the P-P system to the P-MP system

The conditions for calculation are ;

Interfered station :	P-MP system
	Technical Specification Table A-4.1
Interfering station :	P-P system
	Technical Specification Table A-6.1
	Spectral characteristics Figure A-6.1

To keep equal to or lower than the allocated C/N (or C/I) for interference from other operators' systems shown in Figure A-3.1 in Appendix-3, the carrier to interference noise power ratio C/Np must satisfy:

$C/Np \geq 25.4$ dB (interference to P-MP system base station)

$C/Np \geq 23.4$ dB (Interference to P-MP system subscriber station)

C/Np can be obtained using the following equation:

$$C/Np = D/Up + IRFmp - DRA$$

Here

D/Up: Desired wave and the undesired wave (coming from P-P system) power ratio at P-MP system receiver input [dB]

IRFmp: IRF for interference from the P-P system to the P-MP system [dB]

DRA: Difference of rainfall attenuation on the desired wave path and on the interference wave path [dB]

D/Up can be obtained using the following equation:

$$D/Up = Prmp - (Ptp - Lftp + Gatp - Ldi + Garmp - Lfrmp - \delta Ga)$$

Here

Prmp: P-MP system desired wave receiver input level [dBm]

Ptp: P-P system transmitter power [dBm]

Lftp: P-P system transmitter feeder loss [dB]

Gatp: P-P system transmitter antenna gain [dBi]

Ldi: Free space propagation loss on the interference wave path [dB]

$$Ldi = 20\log_{10}\left(\frac{4\pi di}{\lambda}\right)$$

di : Length of interference wave path [m]

λ : wave length [m]

Garmp: P-MP system receiver antenna gain [dBi]

Lfrmp: P-MP system receiver feeder loss [dB]

δGa: Expected interference suppression by directivity of antennas of both the P-P system and the P-MP system. [dB]

According to Figure A-4.1 in Appendix-4, the P-MP system shall be as follows:

Receiving filter: Equal split square root 50 % roll-off filter

Out of band attenuation 40 dB

Channel spacing: Symbol rate × 1.5

The IRF value calculation considering the spectral characteristics of the P-P system shown in Figure A-6.1, is resulted as Figure A-6.2. As the figure shows, the IRF values obtained vary greatly depending on the transmission speed, if no guard band is set.

(2) Interference from the P-MP system to the P-P system

The conditions for calculation are ;

Interfered station :	P-P system
	Technical Specification Table A-6.1
Interfering station :	P-MP system
	Technical Specification Table A-4.1
	Spectral characteristics: Figures 2.1 and 2.2 in Chapter 2.

To keep equal to or lower than the allocated C/N (or C/I) value for interference from other operator' systems, the carrier to interference noise power ratio C/Nmp must satisfy:

$$C/Nmp \geq 28.7 \text{ dB}$$

The C/Nmp can be determined from the following equation:

$$C/Nmp = D/Ump + IRFp - DRA$$

Here

D/Ump:	Desired wave and undesired wave (coming from P-MP system) power ratio at P-P system receiver input [dB]
IRFp:	IRF for interference from corresponding P-MP system to P-P system [dB]

D/Ump can be obtained using the following equation:

$$D/Ump = Prp – (Ptmp – Lftmp + Gatmp – Ldi + Garp – Lfrp - \delta Ga)$$

Here

Prp:	P-P system desired wave receiver input level [dBm]
Ptmp:	P-MP system transmitter power [dBm]
Lftmp:	P-MP system transmitter feeder loss [dB]
Gatmp:	P-MP system transmitter antenna gain [dBi]
Ldi:	Free space propagation loss on the interference wave path [dB]
Garp:	P-P system receiver antenna gain [dBi]
Lfrp:	P-P system receiver feeder loss [dB]
δGa:	Expected interference suppression by directivity of antennas of both the P-P system and the P-MP system [dB]

The IRF value for interference from the P-MP TDMA system or P-MP FDMA system to the P-P system is shown in Figures A-6.3 and A-6.4. As these figures show, the values obtained vary markedly depending on the transmission speed.

(3) Example calculation

As an example, the relationship between the interference wave path length and the interference wave suppression (dB) is shown in Figure A-6.5.

Technical Specification of	P-MP system	Table A-4.1
Technical Specification of	P-P system	Table A-6.1

DRA = 0 dB

(4) Summary

The IRF values in shared conditions vary widely according to the adjacent systems. Accordingly, it is desirable to determine the interference wave path length : di, and the interference wave suppression given by the antenna directivity : δGa, to satisfy the required C/N using predetermined IRF value for each adjacent system.

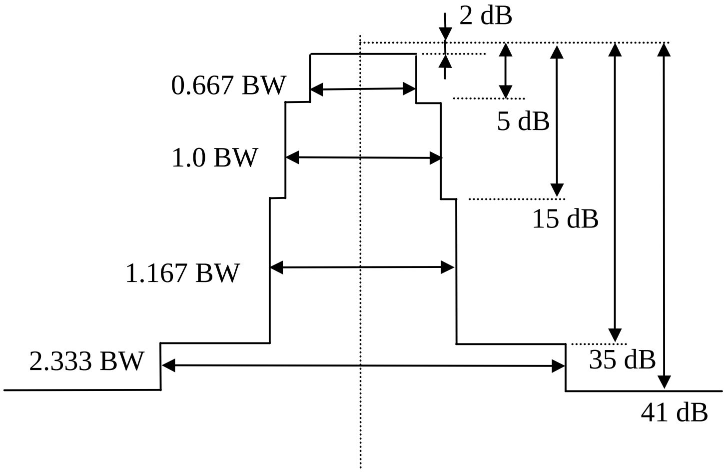


Figure A-6.1 Example of 156Mbps 16QAM P-P system spectrum

Table A-6.1 Specification of a P-P system used for calculation model

Item	Specification
Modulation method	16QAM
Antenna gain	38 dBi
Feeder loss	0 dB
Transmitter power	18.0 dBm
Receiver input level (clear air)	-33 dBm
Receiver saturation level	-20 dBm
Symbol rate	42.8 Msymbol/sec
Channel spacing	60 MHz
Receiving filter	Equal split square root 50 % roll-off filter Out of band attenuation 40 dB
C/N allocated for interference from different operators' system	28.7 dB

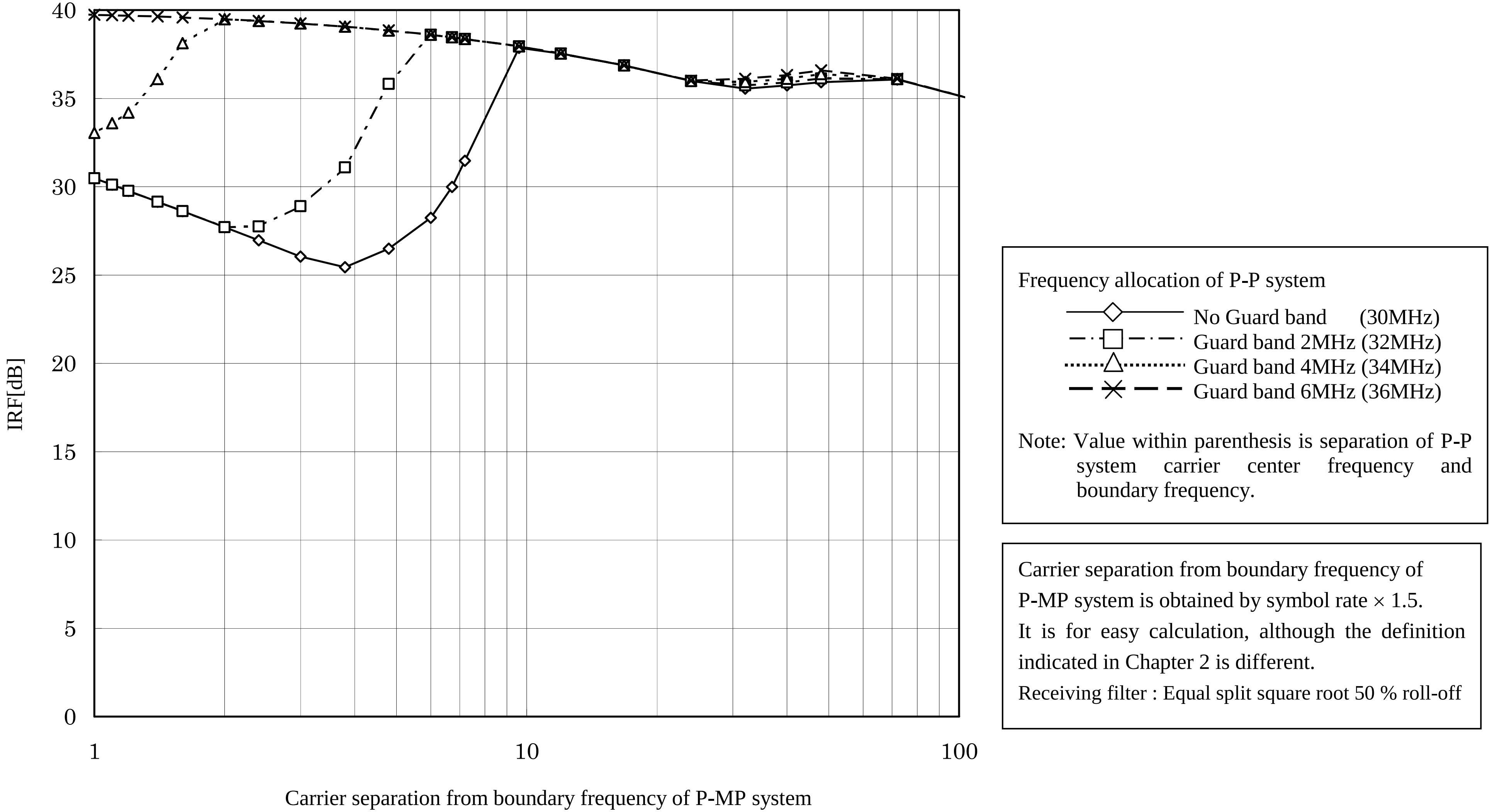
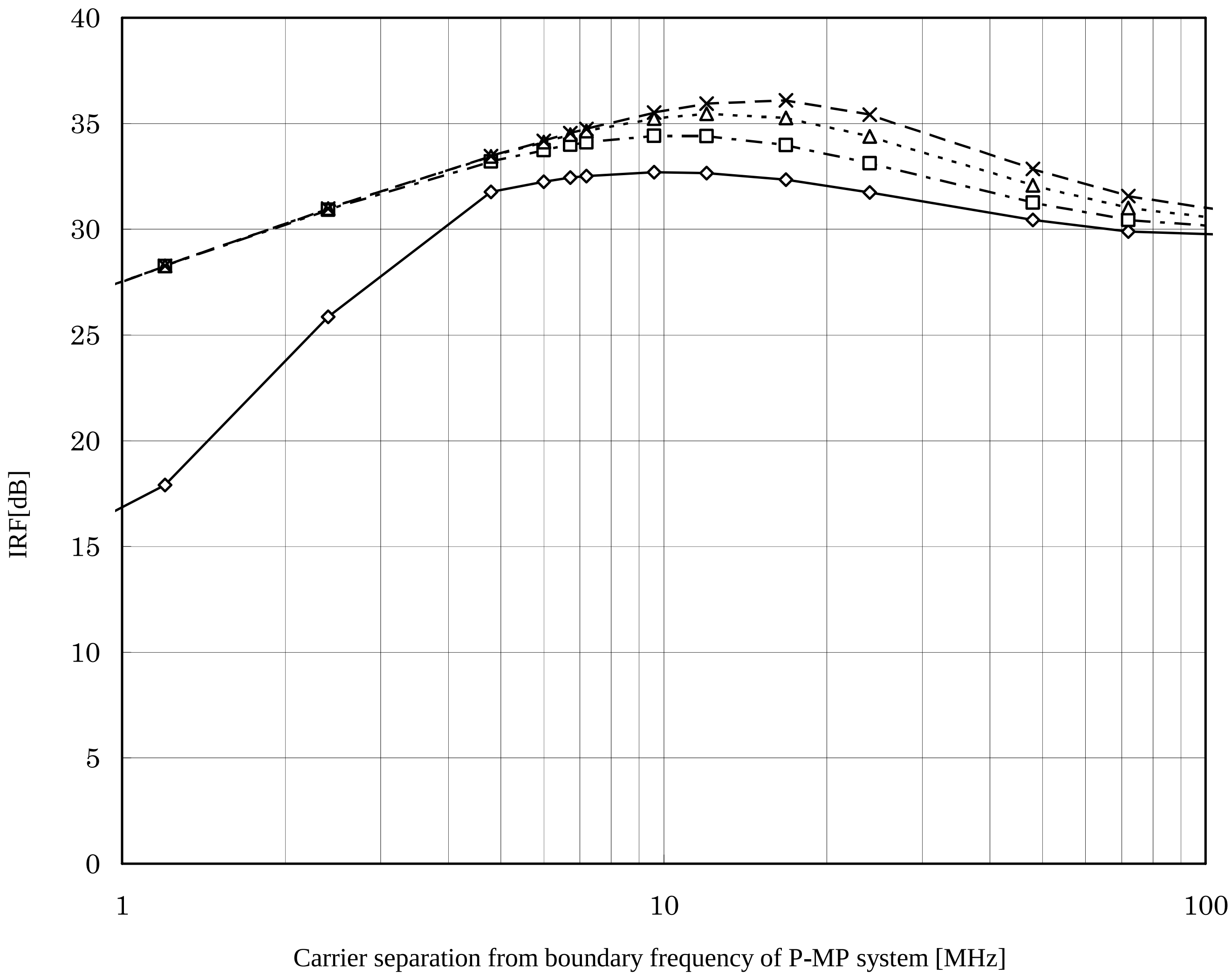


Figure A-6.2 IRF value for the P-P system (Table A-6.1) to the P-MP system (Table A-4.1) interference

ARIB STD-T59



Frequency allocation of P-P system

- No Guard band (30MHz)
- Guard band 2MHz (32MHz)
- Guard band 4MHz (34MHz)
- Guard band 6MHz (36MHz)

Note: Value within parenthesis is separation of P-P system carrier center frequency and boundary frequency.

Carrier separation from boundary frequency of P-MP system is obtained by symbol rate × 1.5.
It is for easy calculation, although the definition indicated in Chapter 2 is different.
Receiving filter : Equal split square root 50 % roll-off

Figure A-6.3 IRF value for the P-MP TDMA system (Table A-4.1) to the P-P system (Table A-6.1) interference

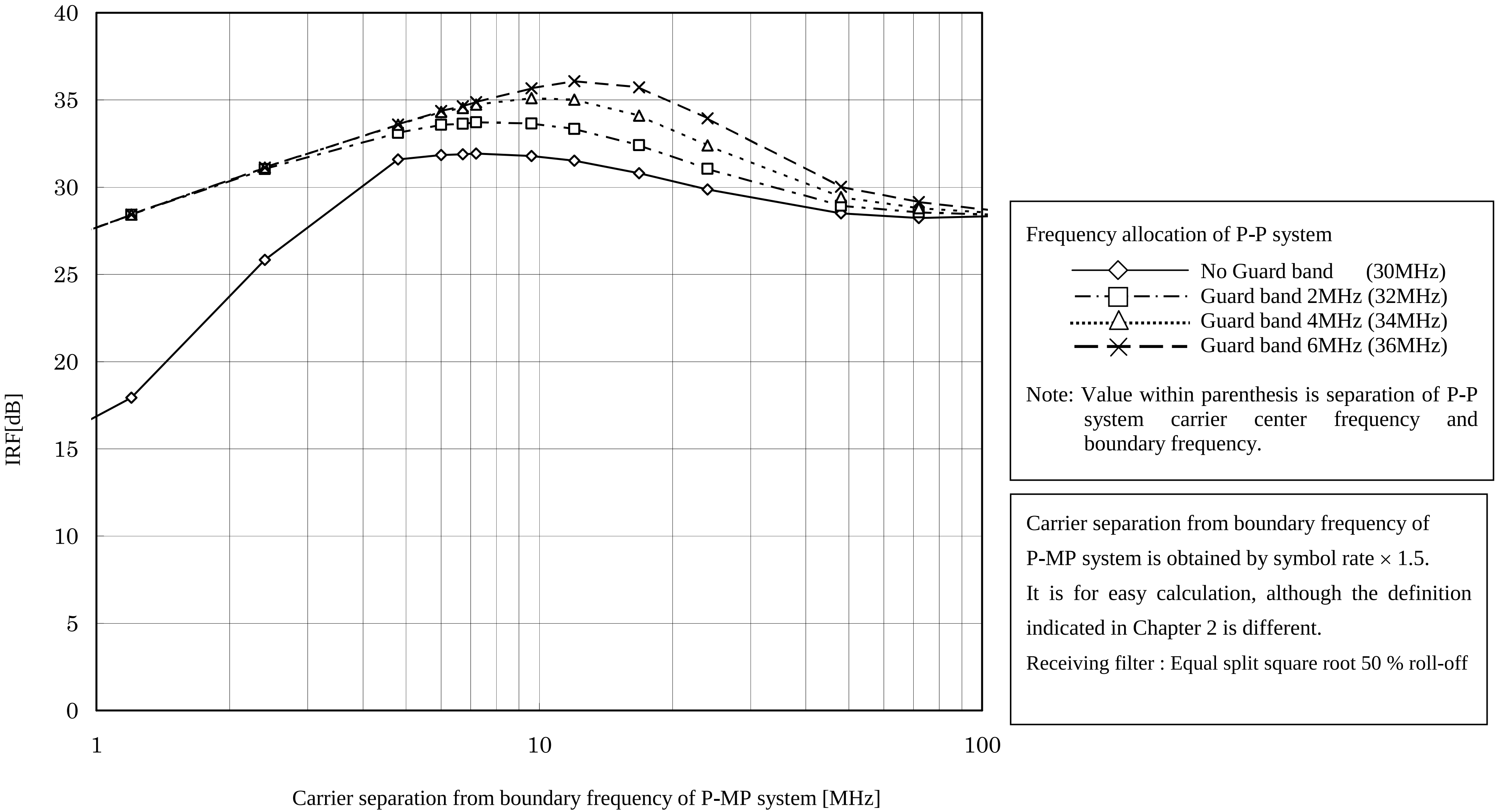


Figure A-6.4 IRF value for the P-MP FDMA system (Table A-4.1) to the P-P system (Table A-6.1) interference

ARIB STD-T59

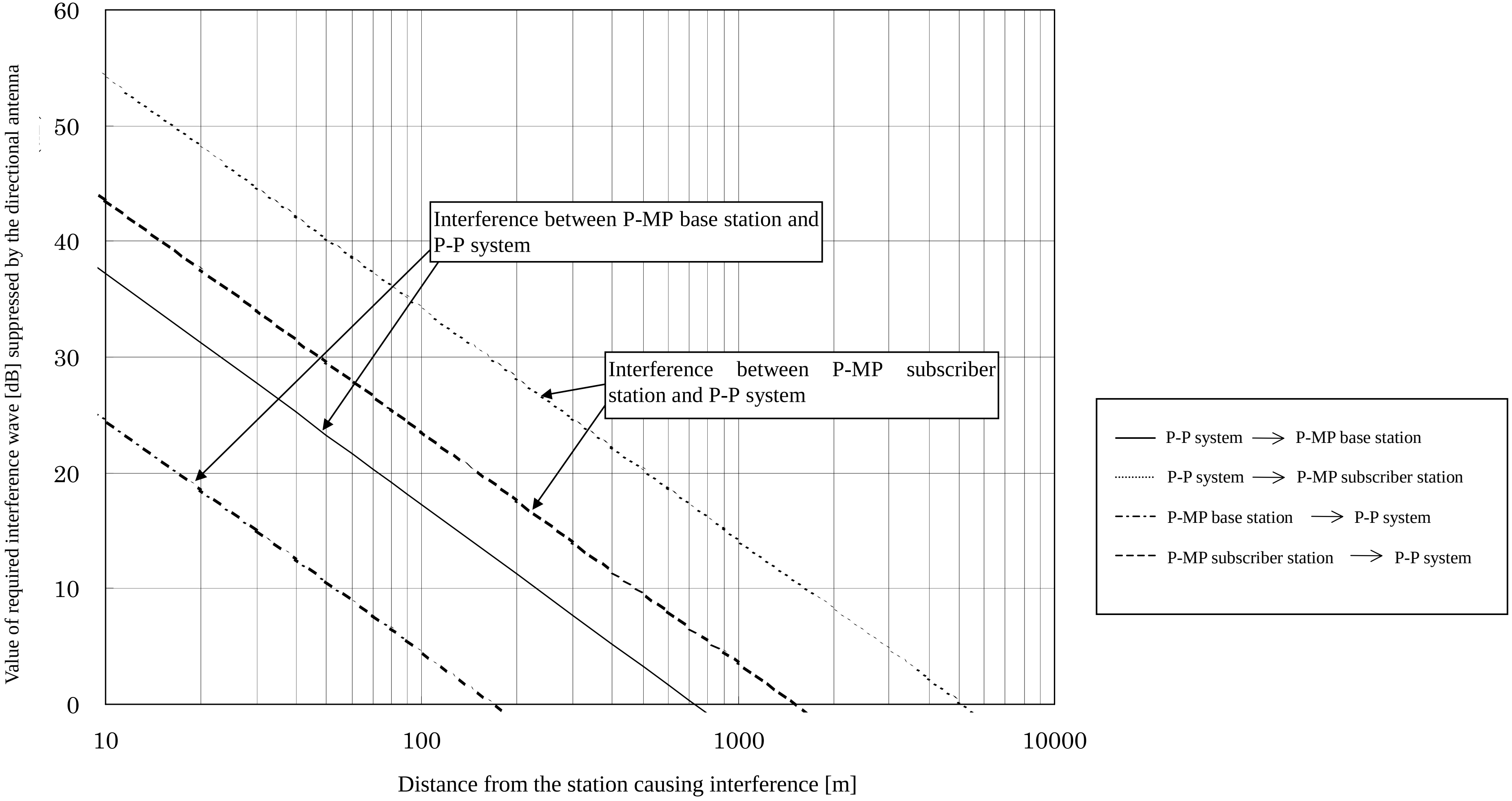


Figure A-6.5 Interference wave path length and interference wave suppression by the directivity of antennas used for the P-MP TDMA system(Table A-4.1) and the P-P system(Table A-6.1)

Appendix-7 Terminology

♦ Carrier separation from boundary frequency
Refer to Item 2.2 (6) in Chapter 2.

♦ Center frequency
This refers to the center of the occupied bandwidth when using radio telecommunications.

♦ Clock frequency
Usually, clock frequency is understood as timing frequency used to determine the timing of presence, absence or changing status of pulses to produce digital signal sequence.
And also clock frequency is frequently used as almost same meaning with Symbol rate.
In this Standard, “clock frequency” is used for the latter.

♦ Differential rain attenuation (DRA)
Difference of rainfall attenuation on desired wave path and on interference wave path.
In general, the threshold value of rainfall attenuation difference corresponding to the required availability is utilized for radio link design. Threshold value is meaningful for only the case that the attenuation on desired wave path is bigger than the attenuation on interference wave path, and can be exceeded within the time corresponding to the required availability.
DRA is depend on path length, angle between desired wave path and interference wave path, frequency band, rainfall intensity and so on.

♦ Equivalent isotropically radiation power (EIRP)
An index that shows the performance of the transmission system. It is a product of the power supplied to the antenna and the isotropic antenna gain in the given direction. When the antenna gain used is at the main beam direction, it can be called as the maximum EIRP.

♦ Frequency division duplex (FDD)
Bi-directional telecommunication method that uses different up link and down link frequencies.

♦ Frequency division multiplex (FDM)
A method to multiplex numbers of channels shifting their frequencies to be occupied different frequency positions.

♦ Frequency division multiple access (FDMA)
A method to realize multiple access assigning different frequencies.

♦ Gaussian-filtered minimum phase shift keying (GMSK)

A minimum phase shift keying (MSK) modulation method with a Gaussian filter used for band limitation of input rectangular waves. This band limitation enables smooth half-wave sinusoidal wave arrays of the MSK modulated wave and thus improves the spectral attenuation characteristic outside the band.

♦ Interference reduction factor (IRF)

The factor applied for easy calculation of interference volume considering mitigation effect.
The IRF expresses mitigation effect volume and is determined by overall filter characteristic of the receiving system, spectral characteristics of interference wave and frequency separation.

♦ Minimum shift keying (MSK)

A modulation method that changes the frequency of the carrier according to the input digital signal. It refers to binary frequency shift keying (FSK) with 0.5 of modulation index obtaining the minimum frequency deviation with orthogonal relation of the mark and space signals.

♦ Phase shift keying

Modulation method for changing phase of carriers according to amplitude variation of input digital signals.
The method where the carrier is modulated by a quadruple digital signal is called quadrature phase shift keying (QPSK). Furthermore the method can be distinguished between modulations which has information on absolute phase and on phase difference, and latter is called as DQPSK (Differential QPSK) when the distinction is needed. Also QPSK includes, as the method achieving suppression of envelop variation, $\pi/4$ shift QPSK where the carrier phase is $\pi/4$ shifted between adjacent symbols, and offset QPSK (OQPSK) where an time offset is added on one of baseband signals to be different the modulation timing between two orthogonal carriers.

♦ Polarized wave

Polarization is the property of electromagnetic waves which characterize the orientation and rotation of the electrical/magnetic vector.
When the electromagnetic vector is in fixed plane, it is known as linear polarization, and the electrical vector plane is known as the polarization plane.
There are two types of linear polarization depending on the polarization plane, as horizontal polarization and vertical polarization.

♦ Power spectral density

A power spectrum shows radio wave power distribution on a frequency axis.
Power spectral density is the power spectrum in a specified bandwidth.

♦ Quadrature amplitude modulation

Method involving amplitude modulation of two orthogonal (phase difference of 90 degrees) carriers in accordance with the input digital signal.

♦ Roll-off rate

A value that shows the filter characteristic in digital transmission. It lies between 0 and 1. The smaller value makes narrower bandwidth signal, and reduces interference to/from other carriers. On the other hand, the lower value brings difficulty to regenerate digital signal at the receiving end.

♦ Symbol rate

For example, in case of binary PSK (BPSK), the modulation and demodulation signals have two levels corresponding to the phase 0 and 180 degrees. On the other hand, in case of QPSK, these have 4 levels corresponding to the phase 0, 90, 180 and 270 degrees. If transmission rate of the modulation signals are same, comparing with the case of BPSK the minimum (unit) time for status change of modulated signal (1 symbol time) for QPSK is twice, the signal changes become slower, and the fewer bands are required. The rate of modulation status change which become slower than the transmission rate of modulation signal by such multi level modulation is known as the symbol rate. For example, if the transmission rate of modulation signals is same as assumed above, 10 Msymbol/sec. for QPSK leads 20 Msymbol/sec. for BPSK.

♦ Time division duplex (TDD)

Bi-directional telecommunication method where one up link or down link frequency is used and divided on a time axis.

♦ Time division multiplex (TDM)

A method to multiplex numbers of channels assigning different time slots.

♦ Time division multiple access (TDMA)

A method to realize multiple access assigning different time slots.

Appendix-8 References

In establishing this standard, references have been made to or quotations have been taken from the following works.

(1) "Intermediate report of the study group on the future of ground maintenance of information communications and the fixed wireless access system"
May 1997
Trunk Communications Division, Radio Department of Telecommunications Bureau, Ministry of Posts and Telecommunications

(2) "Technical conditions of the fixed wireless access system " June 1998
Report from Telecommunications Technology Council

(3) "Basic concepts for the introduction of the new fixed wireless access system using quasi-millimeter-wave- and millimeter-wave-band frequencies. "
September 18, 1998
Trunk Communications Division, Radio Department of Telecommunications Bureau, and Telecommunications Policy Division, Telecommunications Business Department of Telecommunications Bureau, Ministry of Posts and Telecommunications

(4) "Basic guideline for the introduction of the new fixed wireless access system using quasi-millimeter-wave- and millimeter-wave-band frequencies. "
December 24, 1998
Trunk Communications Division, Radio Department of Telecommunications Bureau, and Telecommunications Policy Division, Telecommunications Business Department of Telecommunications Bureau, Ministry of Posts and Telecommunications

FIXED WIRELESS ACCESS SYSTEM
USING QUASI-MILLIMETER-WAVE-
AND MILLIMETER-WAVE-BAND
FREQUENCIES
POINT-TO-MULTIPOINT SYSTEM

ARIB STANDARD

ARIB STD-T59 VERSION 1 REV.-1

Version 1	March	1999
Version 1 Rev.-1	March	2000

Published by

Association of Radio Industries and Businesses

Nittochi Bldg. 14F
1-4-1 Kasumigaseki, Chiyoda-ku, Tokyo 100-0013, Japan

TEL 81-3-5510-8590
FAX 81-3-3592-1103

Printed in Japan