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

ARIB STANDARD

VERSION 1.1

ARIB STD－T58

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Association of Radio Industries and Businesses (ARIB)

General notes for the English version of the ARIB Standard T58

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The original "FIXED WIRELESS ACCESS SYSTEM USING QUASI-MILLIMETER-WAVE- AND MILLIMETER-WAVE-BAND FREQUENCIES POINT-TO-POINT SYSTEM(ARIB STD-T58)" is written in Japanese and has been approved(Version 1 Rev.-1 release on October 12, 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-point 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.

The extent stipulated in this Standard is the minimum requirements for telecommunications. For practical use of this Standard, it will be needed that telecommunications operators who construct the system consists of “Point-to-point fixed wireless access system using quasi-millimeter-wave- and millimeter-wave-band frequencies.” use rules and standard values which each operator can establish without the deviation of this Standard.

ARIB hopes that this Standard will be actively used by radio equipment manufacturers, telecommunications operators and users.

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

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Chapter 1　Scope

1.1 Overview

This Standard applies to the point-to-point radio equipment (hereinafter called "P-P system") among the radio stations for subscriber radio access communications using frequencies of quasi-millimeter wave band and millimeter wave band as defined in Item 25, Clause 7 of the Radio Equipment Regulation.
The P-P system consists of radio transmission paths (including radio relay transmission paths) that link the terrestrial mobile station (hereinafter called "Base Station") installed by a telecommunication operator and the terrestrial mobile station (hereinafter called "Subscriber Station") installed at residence.

1.2 Scope of Application

As Shown in figure 1.1, basically the P-P system consists of the base station and the subscriber station.
This Standard prescribes conditions to be met by transmitter, receiver and antenna used among the base stations, the subscriber stations and the relay stations.

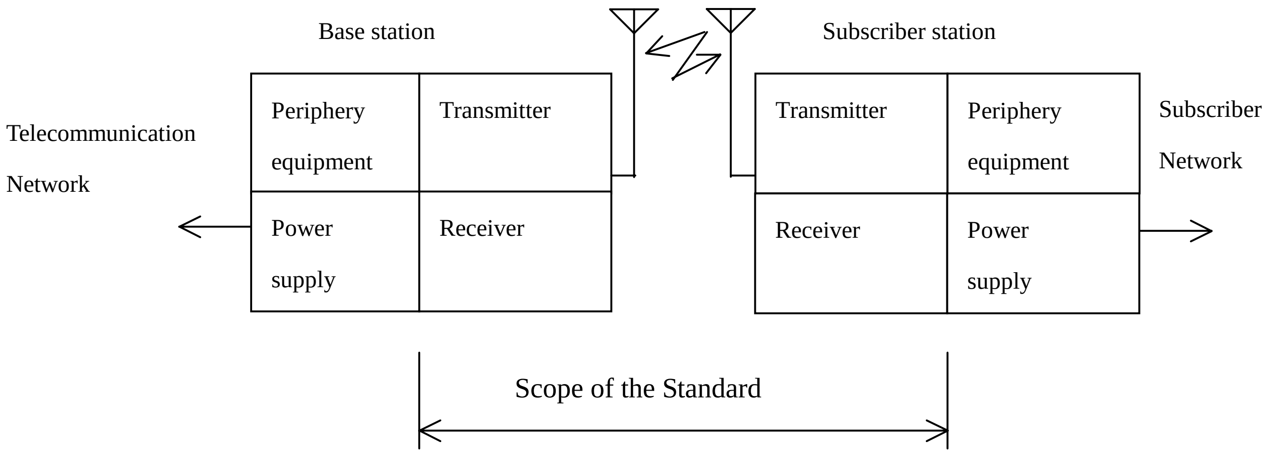


Figure 1.1　P-P system configuration

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 the 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) Communication system (Equipment Regulation: Clause 49.19)

Communication system shall be a Frequency Division Duplex system (FDD)

(2) Modulation method (Equipment Regulation: Clause 49.19, Public Notice No. 604, 1998)

Modulation method shall be Quadrature Phase Shift Keying, 4-state Frequency Shift Keying or 16-level, 32-level or 64-level Quadrature Amplitude Modulation.

(3) Frequency bands (Equipment Regulation: Clause 7)

22 GHz band : Frequencies of more than or equal to 22 GHz and less than or equal to 22.4 GHz, more than or equal to 22.6 GHz and less than or equal to 23 GHz shall be used.

26 GHz band : Frequencies of more than or equal to 25.25 GHz and less than or equal to 27 GHz shall be used.

38 GHz band : Frequencies of 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.

2.2 Transmitter

(1) 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 500 mW or less. Note that the transmitter power may be controllable.

(2) Permissible deviation of transmitter power (Equipment Regulation: Clause 14)

Transmitter power shall be within the range of +50 % and –50 % of specified transmitter power.

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.

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

The permissible spurious emission shall be 50 μW or less.

(4) Permissible frequency tolerance

The permissible frequency tolerance shall be $\pm 2 \times 10^{-5}$.

(5) Power leakage to adjacent frequency block

(A) Quadrature Phase Shift Keying

(a) The power spectral level of the first side band ($\Delta f/f_c = 1.5$) and second side band($\Delta f/f_c = 2.5$) shall be respectively –25 dB and –41 dB or lower compared to the maximum value as shown in Figure 2.1.

Here, Δf : Offset frequency from the center frequency

f_c : Clock frequency

(b) In case that the specification in (a) is not satisfied, the IRF for interference from corresponding system (to be used) to the 16QAM 156Mbps system (Modulation method is 16-level Quadrature Amplitude Modulation and its main signals transmission capacity is 156Mbps: hereinafter called “16QAM 156Mbps system”) in adjacent block located with the carrier separation from boundary frequency specified in Item 2.2 (6) shall be more than 33 dB.

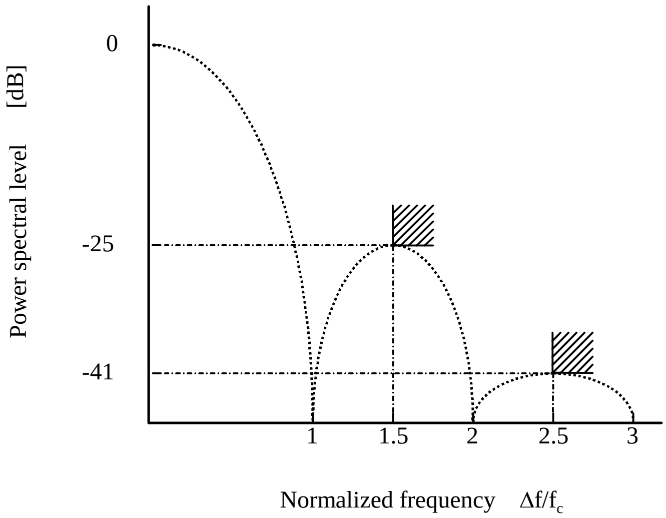


Figure 2.1 Power spectral mask of Quadrature Phase Shift Keying

(B) 4-state Frequency Shift Keying

(a) Power spectral density per 1MHz shall be –AdB or lower compared to the transmitter power as shown below within the range of $0.5 \le \Delta f/f_b < 2.5$ indicated in Figure 2.2.

$$A = 11 + 0.4 (\Delta f/f_b \times 100 - 50) + 10\log_{10} f_b$$

Here, $11 \le A \le 56$

f_b : Frequency bandwidth (5MHz for 6Mbps system / 10MHz for 12Mbps system / 40MHz for 45Mbps system

(b) In case that the specification in (a) is not satisfied, the IRF for interference from corresponding system (to be used) to the 16QAM 156Mbps system in adjacent block located with the carrier separation from boundary frequency specified in Item 2.2 (6) shall be more than 33 dB.

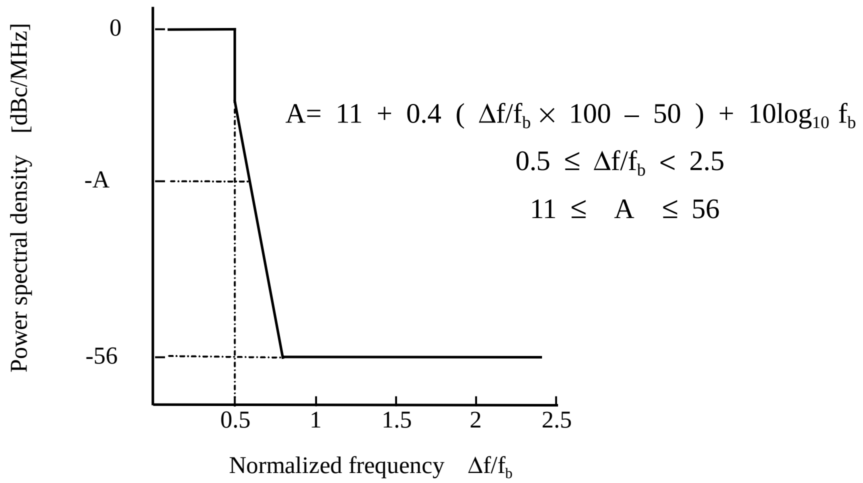


Figure 2.2 Power spectral mask of 4-state Frequency Shift Keying

(C) 16-level, 32-level, or 64-level Quadrature Amplitude Modulation

(a) The power spectral level of the first side band ($\Delta f/f_c = 1.5$) and second side band ($\Delta f/f_c = 2.5$) shall be respectively –36 dB and –41 dB or lower compared to the maximum value as shown in Figure 2.3.

(b) In case that the specification in (a) is not satisfied, the IRF for interference from corresponding system (to be used) to the 16QAM 156Mbps system in adjacent block located with the carrier separation from boundary frequency specified in Item 2.2 (6) shall be more than 33 dB.

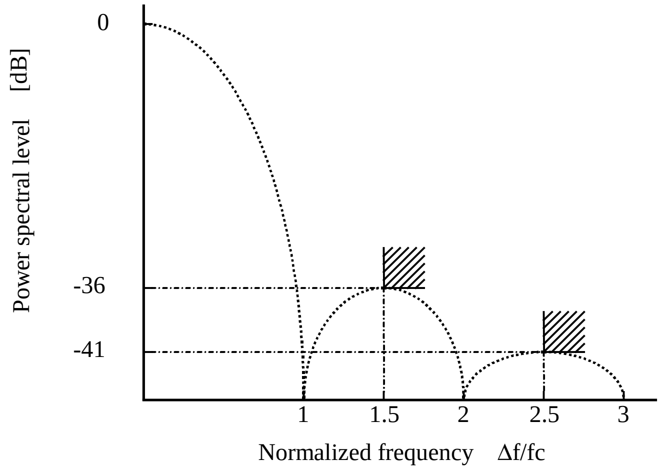


Figure 2.3 Power spectral mask of 16-level, 32-level, or 64-level Quadrature Amplitude Modulation

(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 Table 2.1 including the permissible frequency tolerance. This concept is shown in Figure 2.4.

In principle, the operator shall use the channel closer to the center of the frequency block with higher priority.

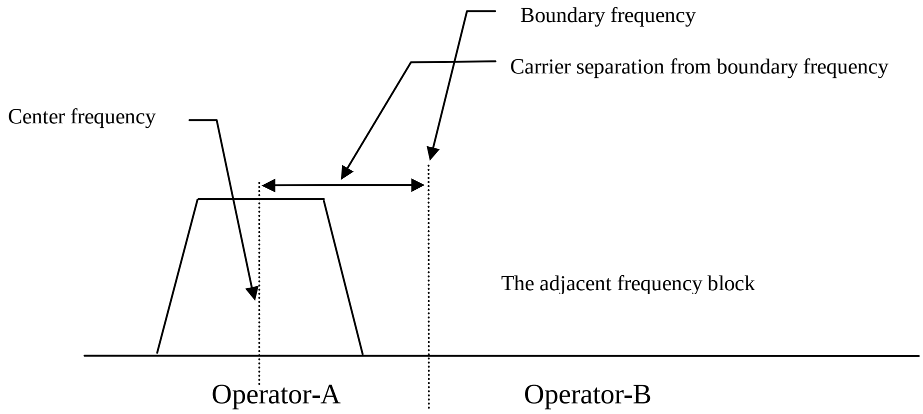


Figure 2.4 Figure showing concept of carrier separation from boundary frequency

Table 2.1 Carrier separation from boundary frequency

System	Modulation method	Clock frequency	Carrier separation from boundary freq. (Note1&2)
QPSK 6Mbps system	Quadrature Phase Shift Keying	4.1 MHz or less	5 MHz
QPSK 12Mbps system		8.2 MHz or less	10 MHz
4FSK 6Mbps system	4-state Frequency Shift Keying	4.1 MHz or less	5 MHz
4FSK 12Mbps system		8.2 MHz or less	10 MHz
4FSK 45Mbps system		25.4 MHz or less	30 MHz
16QAM 52Mbps system, etc.	16-level, 32-level, and 64-level Quadrature Amplitude Modulation	14.3 MHz or less	10 MHz
16QAM 156Mbps system, etc.		42.8 MHz or less	30 MHz

(Note1) If the Carrier separation from boundary frequency listed in this table becomes less than the sum of "permissible frequency deviation specified in Item 2.2 (4)" and "1/2 of permissible occupied frequency bandwidth", the summed value shall be used as the carrier separation from boundary frequency.

(Note2) If the IRF for the interference from the corresponding system (to be used) to the 16QAM 156Mbps system shown in Appendix-1 allocated with the carrier separation from boundary frequency shown in this table is more than 33 dB, the carrier separation from boundary frequency of the relevant system can be narrowed.

(7) Permissible occupied bandwidth (Equipment Regulation: Clause 6, Public Notice No.604, 1998)

The occupied bandwidth is the bandwidth which contains 99 % of the total average power. In other words, average power of the emission in the upper outside portion (higher than the upper edge) and in the lower outside portion (lower than the lower edge) of the occupied bandwidth is 0.5 % of the total average power respectively.

Its permissible value shall be calculated by using the formula shown in right column of Table 2.2 for corresponding modulation scheme in left column.

Fractions less than 500 kHz shall be rounded up to 500 kHz, and fractions exceeding 500 kHz and less than 1 MHz shall be rounded up to 1 MHz.

Table 2.2 Permissible occupied bandwidth

Modulation method	Permissible occupied bandwidth
Quadrature Phase Shift Keying	Clock frequency [MHz] $\times$ (1+α) α: the roll-off rate (The roll-off rate shall be 0.5 or less.)
4-state Frequency Shift Keying	Clock frequency [MHz] $\times$ 1.6 (modulation index: 0.4 rad) Clock frequency [MHz] $\times$ 2.0 (modulation index: 0.7 rad)
16-level Quadrature Amplitude Modulation 32-level Quadrature Amplitude Modulation 64-level Quadrature Amplitude Modulation	Clock frequency [MHz] $\times$ 1.3 (The roll-off rate shall be 0.5 or less.)

2.3 Receiver

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

It shall not exceed 4 nW for frequencies lower than 1 GHz, and 20 nW for frequencies higher than or equal to 1 GHz.

2.4 Antenna

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

The EIRP when transmitter power is applied shall not exceed the following EIRP mask.

For 22 GHz band, 26 GHz band system

$EIRP = 73 - 3.8\,\theta$ [dBm] $(0° \le \theta \le 5°)$

$EIRP = 68.5 - 20.8 \log_{10} \theta$ [dBm] $(5° < \theta < 100°)$

$EIRP = 26.9$ [dBm] $(100° \le \theta)$

For 38 GHz band system

$EIRP = 71 - 3.3\,\theta$ [dBm] $(0° \le \theta \le 6°)$

$EIRP = 67.3 - 20.9 \log_{10} \theta$ [dBm] $(6° < \theta < 140°)$

$EIRP = 22.4$ [dBm] $(140° \le \theta)$

θ: Angle from main radiation direction of antenna

(2) Polarization (Equipment Regulation: Clause 49.19)
Shall be either vertical or horizontal polarization.

2.5 Monitoring and Controlling Function

(1) The system shall have the monitoring and controlling functions required for system operation.

(2) Auxiliary signals for monitoring and controlling shall be transmitted adding to the main digital signal sequence by time division multiplex techniques and shall not be transmitted using special carriers 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) Power spectral level

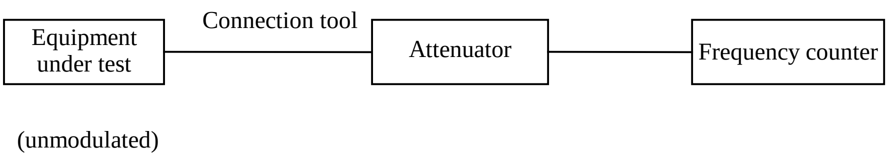
3.1.2 Common conditions

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

(2) 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

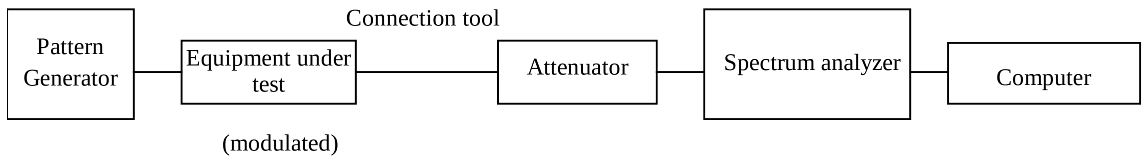
(1) Transmission shall be made after setting the designated channel.
(2) As a rule, unmodulated signal is applied.
(3) Measurement shall be made at the antenna terminal or the measurement monitor terminal. In the case that these terminals can not be used for measurement, measurement shall be made using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

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

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

(3) 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.

(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
Multiple sweeps of the spectrum analyzer are made to determine the average amplitude of same data points.

(2) Fetching data
Values of all data points are fetched into array variables after repeating the necessary number of sweeps.

(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".

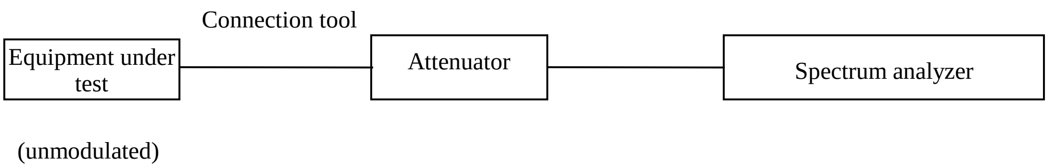
(5) Calculation of the lower threshold frequency
The power value is summed up in up-ward sequence starting from the minimum frequency data. When this value becomes equal to 0.5 % of the total power, the last data point is recorded as the threshold point. Frequency corresponding this data point is recorded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

3.4.3 Conditions of equipment under test

(1) Transmission shall be made after setting the test frequency.
(2) As a rule, unmodulated signal is applied.
(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.

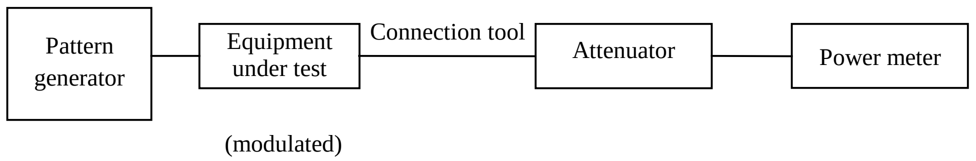
3.4.4 Measurement procedure

(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.

3.5.3 Conditions of equipment under test

(1) Transmission shall be made after setting the designated channel.

(2) As a rule, modulated signal is applied.

(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.

3.5.4 Measurement procedure

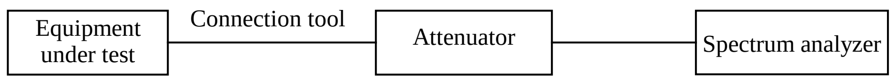
(1) The power meter is calibrated at zero power.

(2) Transmission is made.

(3) The average power is measured.

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

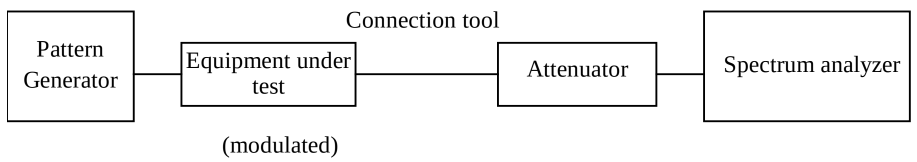
(1) The equipment is set to the designated channel.
(2) Transmission is ceased and the equipment is placed in the receiving mode.
(3) Measurement shall be made at the antenna connection flange. In the case of equipment for which the connection tool cannot be connected to the antenna connection flange 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 Power spectral level

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 times clock frequency or more
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
	Here, 1 MHz for 4-state Frequency Shift Keying

Video bandwidth:	0.1 kHz for channel spacing of 14 MHz or less 0.3 kHz for channel spacing of more than 14 MHz up to 60 MHz
Sweeping time:	Automatic
Y scale:	10 dB/Div
Input level:	The spectral level at the center frequency shall be at least 50 dB or more higher than the spectrum analyzer noise level. However, in measurement for 4-state Frequency Shift Keying modulation, the carrier wave level shall be at least 60 dB or more higher than the spectrum analyzer noise level. When measuring, input signal level shall be set to a low value possible by adjusting an attenuator; if input level is too high, the higher power level of the side-band wave is caused by cross modulated distortion in the spectrum analyzer.

(2) 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.)

3.7.3 Conditions of equipment under test

(1) Transmission shall be made after setting the test frequency. 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. The measurement monitor terminal is required to output the equivalent signal characteristic to the main signal for the respective measurement items, furthermore, it should be required with no influence to the main signal during measurement and to be able to supply the appropriate signal output to the measurement equipment.

3.7.4 Measurement procedure

(1) Quadrature Phase Shift Keying or Quadrature Amplitude Modulation

It should be required to measure difference of the maximum power spectrum of the fundamental wave and the power spectrum of the first side band wave ($\Delta f/f_c = 1.5$) or second side band wave ($\Delta f/fc = 2.5$) each (Δf: the difference of frequency, f_c: clock frequency). The maximum measured value is regarded as 0 dB.

(2) 4-state Frequency Shift Keying

It should be required to measure difference of the carrier wave power and the power spectrum within the $0.5 \leq \Delta f/f_b < 2.5$ (Δf: the difference of frequency, f_b: frequency bandwidth). The carrier wave power measured value is regarded as 0 dB.

Chapter 4　Terminology

♦ Carrier separation from boundary frequency

Refer to Item 2.2(6) in Chapter 2.

♦ 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.

♦ 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.

♦ Forward error correction(FEC)

The method to be used to correct the errors occurred in transmission line. In the transmission side, the digital bit stream is processed by insertion of the redundant error correction code or redundancy adding conversion according to the particular coding algorithm, and then transmitted. In reception side, the errors are corrected according to the particular decoding algorithm.

♦ Frequency block

The frequency block is a 60 MHz frequency bandwidth allocated to the operator.　As a rule, an upper band and a lower　band (total of 120 MHz) are allocated as a unit.

♦ Frequency division duplex (FDD)

Bi-directional telecommunication method that uses different up link and down link frequencies.

♦ Frequency shift keying (FSK)

In the FSK, the sub-carrier or main carrier frequency is shifted by the predefined frequency difference.

♦ 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.

♦ Main Signal Transmission Capacity

Of the information transmitted in the radio transmission section, the transmission rate of the payload information sent or received to and from the transmission facility (excluding the additional information used for radio communication such as FEC and supervisory control signal) is called the main signal transmission capacity.

♦ 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

The power spectrum divided by the occupied bandwidth.
It is normally represented by dBm/Hz.

♦ Power spectral level

The relative value of power spectrum based on its maximum value is called the power spectral level. It is normally represented by dB.

♦ Power spectrum

The radio wave energy elements indicated on the frequency axis.

♦ 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.

♦ Side band waves

Frequency elements appeared above or below the carrier frequency when the carrier wave is modulated.
Waves are called the first side band wave, the second side band wave and etc. counting from the waves nearer to the carrier frequency.

♦ 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 is 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

APPENDIX

Appendix-1 Calculation Basis of Power Leakage to Adjacent Frequency Blocks and the Frequency Separation between Interfering Carrier and Interfered Carrier

The purpose of this appendix is to study interference between P-P systems used in adjacent frequency blocks and to show the basis for the calculation of the power leakage to adjacent frequency blocks specified in Item 2.2 (5) and the frequency separation between interfering carrier and interfered carrier specified in Item 2.2 (6) in Chapter 2. In this study, the 22GHz band is used as an example.

(1) Model of the receiver for the interfered station

The high spectral efficiency system tends to be affected more than low spectral efficiency system by interference. Therefore from the standpoint of spectral efficiency, this appendix selects the 16QAM 156Mbps system with following parameters for the interfered side.

(A) Receiver input level (antenna terminal) : −33 dBm (antenna diameter 60 cm)
: −39 dBm (antenna diameter 30 cm)

(B) Maximum receiver input level (saturation level) : −20 dBm

(C) Filter characteristics of the receiver

Equal split square root 50 % roll-off filter

Out of band attenuation : 40 dB

(D) Clock frequency : 42.8 MHz

(E) Antenna gain : 38 dBi (antenna diameter 60 cm)
: 32 dBi (antenna diameter 30 cm)

(2) Model of transmitter for the interfering station

Model is shown in the Table A-1.1.

Table A-1.1 Model of Transmitter on the Interfering Station

Modulation method	System	Clock frequency	Occupied bandwidth	Power leakage to adjacent blocks
Quadrature Phase Shift Keying (QPSK)	QPSK 6Mbps	4.1 MHz	5.3 MHz	See Item 2.2 (5) A in Chapter 2.
	QPSK 12Mbps	8.2 MHz	10.5 MHz	
4-state Frequency Shift Keying (4FSK)	4FSK 6Mbps	4.1 MHz	4.3 MHz	See Item 2.2 (5) B in Chapter 2.
	4FSK 12Mbps	8.2 MHz	9.8 MHz	
	4FSK 45Mbps	25.4 MHz	36.7 MHz	
16-level Quadrature Amplitude Modulation (16QAM)	16QAM 52Mbps	14.3 MHz	18.4 MHz	See Item 2.2 (5) C in Chapter 2.
	16QAM 156Mbps	42.8 MHz	55.0 MHz	

(3) Calculation of the frequency separation for satisfying the required IRF values

The frequency separation between interfering carrier and interfered carrier was calculated to get required IRF values of 33 dB, considering the cost of radio equipment, the spectral efficiency, possible coexistence distance, etc. The calculation result is shown in the Table A-1.2.

Table A-1.2 Calculation Result of Frequency Separation for satisfying the required IRF values

Interfering \ Interfered		16QAM 156Mbps System		Carrier separation from boundary Freq. on interfering carrier
		Required IRF	Frequency separation between interfering and interfered carrier	
Quadrature phase shift keying (QPSK)	QPSK 6Mbps system	33 dB	35 MHz	5 MHz
	QPSK 12Mbps system	33 dB	40 MHz	10 MHz
4-state frequency shift keying (4FSK)	4FSK 6Mbps system	33 dB	35 MHz	5 MHz
	4FSK 12Mbps system	33 dB	40 MHz	10 MHz
	4FSK 45Mbps system	33 dB	60 MHz	30 MHz
16-level Quadrature amplitude modulation (16QAM)	16QAM 52Mbps system (Note)	32 dB	40 MHz	10 MHz
	16QAM 156Mbps system	33 dB	60 MHz	30 MHz

(Note) 32dB is used for 16QAM 52Mbps system as the required IRF values instead of 33 dB considering the spectral efficiency.

(4) Required separation distance between interfering station and interfered station

(A) The case of a study for parallel radio links

Frequency arrangement is shown in Figure A-1.1. Operator-A and Operator-B respectively use CH1 and CH2. A study model for parallel radio links is shown in Figure **A-**1.2.

It is assumed that Station-a and Station-b of Operator-A and Station-c and Station-d of Operator-B configure parallel radio links under the severest interference condition and reduction of interference by the directivity of antenna cannot be expected.

Since these links are parallel paths, the DRA (Differential rain attenuation: Difference of rainfall attenuation on the desired wave path and the interference wave path) is ignored.

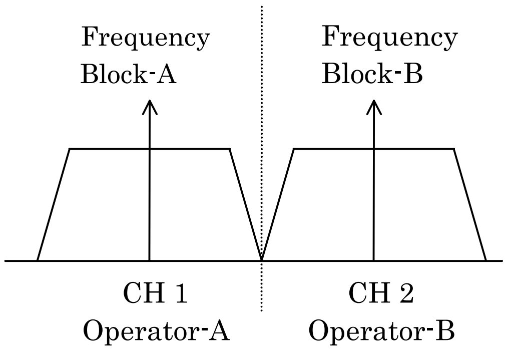


Figure A-1.1 Frequency Arrangement

Under the above conditions, interference from Operator-B’s interfering station (Station-c) to Operator-A’s interfered station (Station-b) is calculated to obtain the required separation distance.

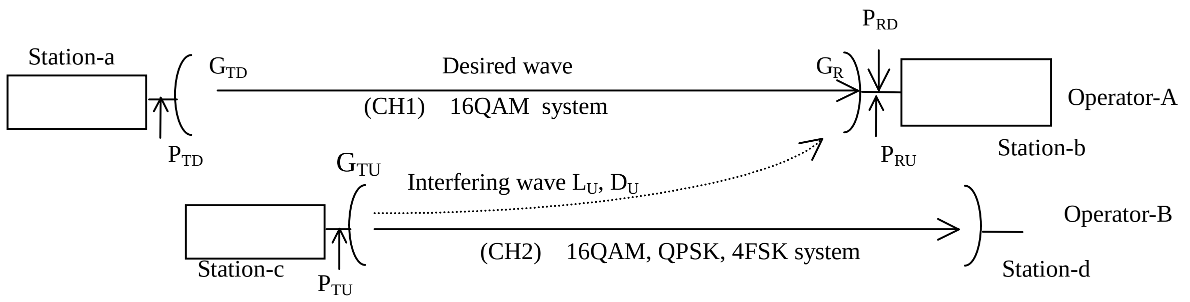


Figure A-1.2 Interference Study Model of Parallel Radio Links

CH1: 16QAM 156Mbps system
CH2: QPSK, 4FSK, or 16QAM system
Station-b : Interfered station
Station-c : Interfering station
Receiver input level of desired wave at Station-b: –33 dBm for antenna diameter 60cm
(–39 dBm for antenna diameter 30cm.)

G_{TU} : Transmitter antenna gain at Station-c [dBi]
G_R : Receiver antenna gain at Station-b [dBi]
P_{TU} : Transmitter power of Station-c [dBm]
P_{RD} : Desired wave receiver input level at Station-b [dBm]
P_{RU} : Interference wave receiver input level at Station-b [dBm]
L_U : Free space propagation loss between Station-c and Station-b [dB]
D_U : Distance between Station-c and Station-b [m]

To satisfy the noise budget in (1) (B) (a) of Appendix-2 (Example of 16QAM), the carrier to interference noise power ratio(C/N) must satisfy:

$C/N \geq 26.3$ dB (Interfering system is 16QAM)
$C/N \geq 28.7$ dB (Interfering system is QPSK or 4FSK)

The C/N can be obtained from the following equation.

$$C/N = P_{RD} - P_{RU} + IRF$$
$$= P_{RD} - (P_{TU} + G_{TU} - L_U + G_R) + IRF$$
$$= -33 \text{ dBm} - (P_{TU} + 38 - L_U + 38) + IRF \text{ (antenna diameter 60 cm)}$$
$$= -39 \text{ dBm} - (P_{TU} + 38 - L_U + 32) + IRF \text{ (antenna diameter 30 cm)}$$

For example, the possible coexistence distance (free space propagation loss L_U) is calculated as follows for interference from the 16QAM 156Mbps system to the 16QAM 156Mbps system.

$$L_U = P_{TU} + 102.3 \text{ dB}$$

The Table A-1.3 shows the free space propagation loss that can coexist in parallel radio links between various systems as the result of using transmitter power of the interfering station as a parameter.

Table A-1.3 Minimum Required Free Space Propagation Loss (dB) for assumed Parallel Radio Links

System \ Output power of interfering station		+27 dBm	+20 dBm	+12 dBm
Quadrature Phase Shift Keying (QPSK)	QPSK 6Mbps system	131.7	124.7	116.7
	QPSK 12Mbps system	131.7	124.7	116.7
4-state Frequency Shift Keying (4FSK)	4FSK 6Mbps system	131.7	124.7	116.7
	4FSK 12Mbps system	131.7	124.7	116.7
	4FSK 45Mbps system	131.7	124.7	116.7
16-level Quadrature Amplitude Modulation (16QAM)	16QAM 52Mbps system	130.3	123.3	115.3
	16QAM 156Mbps system	129.3	122.3	114.3

The above propagation loss is converted into the path length (in case of 23.0 GHz) in the Table A-1.4.

Table A-1.4 Minimum Required Separation Distance (km) for assumed Parallel Radio Links

System \ Output power of interfering station		+27 dBm	+20 dBm	+12 Bm
Quadrature Phase Shift Keying (QPSK)	QPSK 6Mbps system	4.0	1.8	0.7
	QPSK 12Mbps system	4.0	1.8	0.7
4-state Frequency Shift Keying (4FSK)	4FSK 6Mbps system	4.0	1.8	0.7
	4FSK 12Mbps system	4.0	1.8	0.7
	4FSK 45Mbps system	4.0	1.8	0.7
16-level Quadrature Amplitude Modulation (16QAM)	16QAM 52Mbps system	3.4	1.5	0.6
	16QAM 156Mbps system	3.0	1.3	0.5

(B) The case that interference level reduction by angle separation is available

If the separation of angle between desired and undesired(interference) wave route is available, the reduction of interference level by the antenna directivity can be considered. The interference study model is shown in the Figure A-1.3.

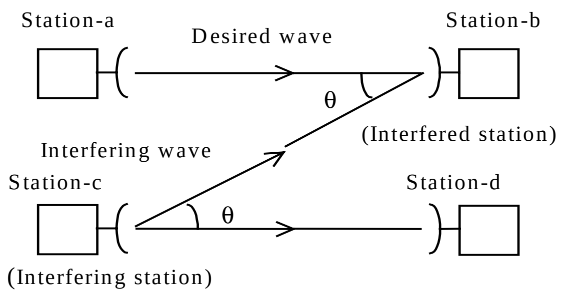


Figure A-1.3 Interference Study Model for the case that the Angle Separation is Available

As an example, required separation distance is calculated using the antenna directivity attenuation of 11.4 dB and 19 dB for angle separation of 3 ° and 5 ° as estimated value by EIRP mask (EIRP = 73–3.8 θ). Here, 8 dB DRA is taken into account.

$L_U = (L_U)_{\theta = 0} - A_U + \text{DRA}$

$(L_U)_{\theta = 0}$: L_U obtained for parallel paths.

A_U : Interference suppression by antenna directivity at Station-c and Station-b

DRA : 8 dB

Table A-1.5 and A-1.6 respectively show the minimum required separation distance (calculated at 23.0 GHz) for angle separation of 3 ° and 5 °

Table A-1.5　Minimum Required Separation Distance (km) for Angle Separation of 3°

System \ Transmitter power of interfering station		+27 dBm	+20 dBm	+12 dBm
Quadrature Phase Shift Keying (QPSK)	QPSK 6Mbps system	0.7	0.3	0.1
	QPSK 12Mbps system	0.7	0.3	0.1
4-state Frequency Shift Keying (4FSK)	4FSK 6Mbps system	0.7	0.3	0.1
	4FSK 12Mbps system	0.7	0.3	0.1
	4FSK 45Mbps system	0.7	0.3	0.1
16-level Quadrature Amplitude Modulation (16QAM)	16QAM 52Mbps system	0.6	0.3	0.1
	16QAM 156Mbps system	0.5	0.2	0.1

Table A-1.6　Minimum Required Separation Distance (km) for Angle Separation of 5°

System \ Transmitter power of interfering station		+27 dBm	+20 dBm	+12 dBm
Quadrature Phase Shift Keying (QPSK)	QPSK 6Mbps system	0.1	0.06	0.02
	QPSK 12Mbps system	0.1	0.06	0.02
4-state Frequency Shift Keying (4FSK)	4FSK 6Mbps system	0.1	0.06	0.02
	4FSK 12Mbps system	0.1	0.06	0.02
	4FSK 45Mbps system	0.1	0.06	0.02
16-level Quadrature Amplitude Modulation (16QAM)	16QAM 52Mbps system	0.1	0.05	0.02
	16QAM 156Mbps system	0.09	0.04	0.02

Appendix-2 Example of Radio Link Design

The fixed wireless access system can adapt to various system architectures, allowing accommodation of many subscribers with high density.

The following are examples of radio link design prepared under the concept of noise budget allocating mostly on interference to avoid the effect of interference. Because of the limitation of available frequency blocks for this system, same frequency block sharing should be considered.

The maximum link distance is calculated as a reference.

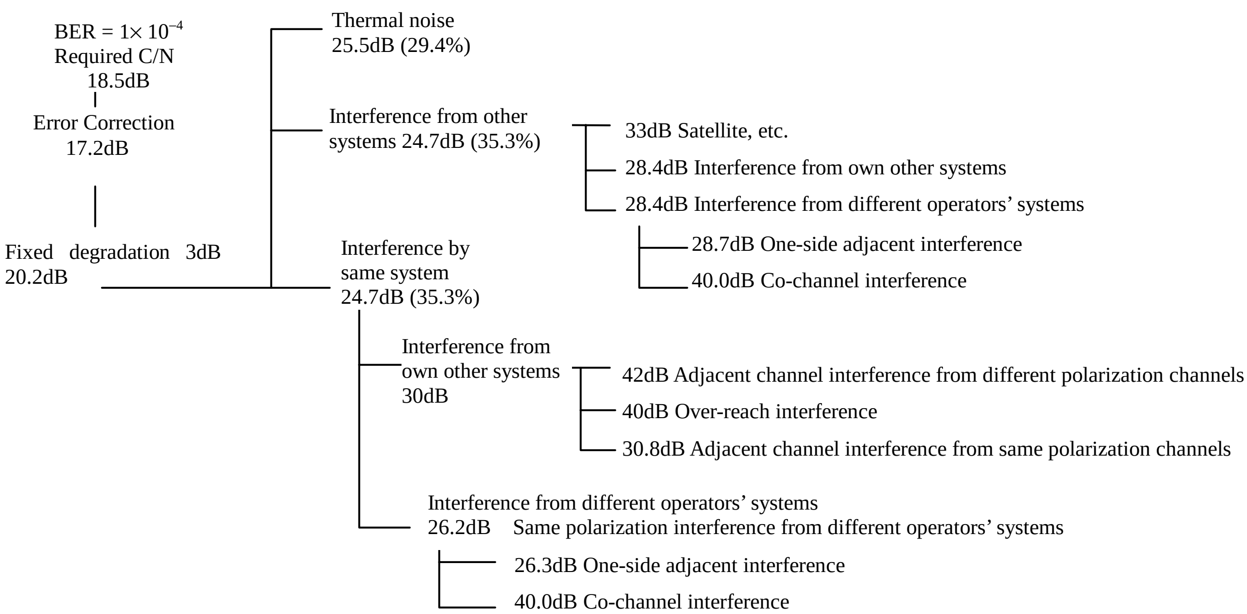
(1) Example of link design of the system with more than 52Mbps transmission rate

(A) Quality

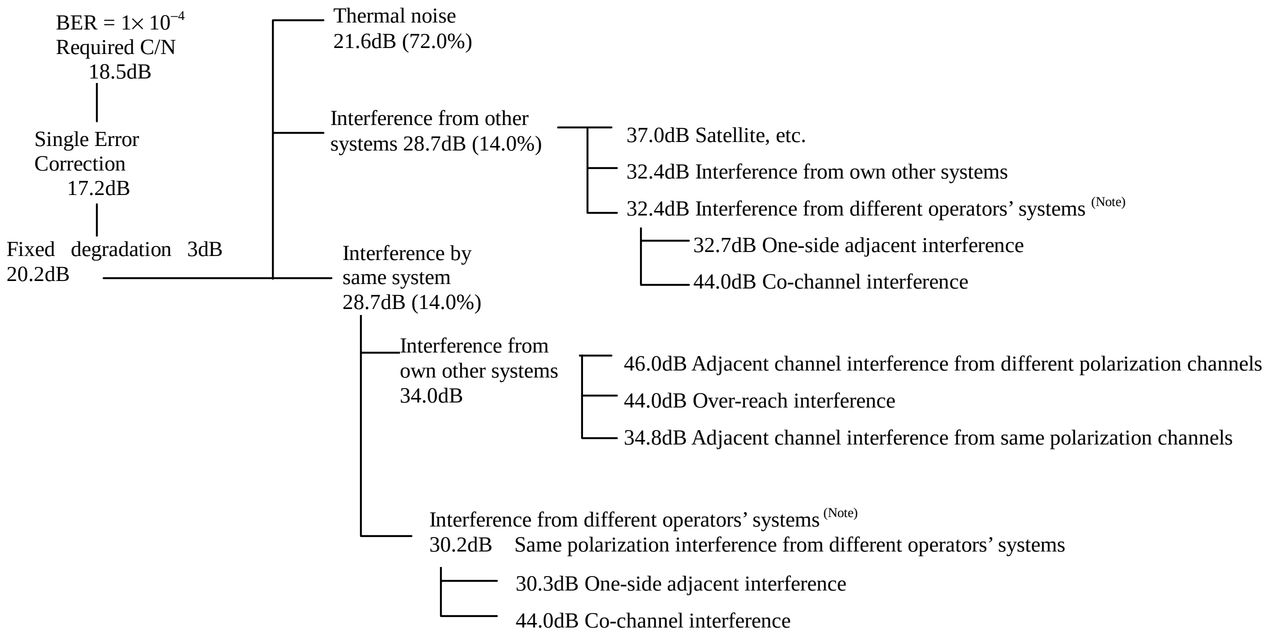
This link design was made assuming a model case that rate exceeding BER = 10^{-4} caused by rainfall (Unavailability) is 0.004 %/year and 0.0004 %/year respectively.

(B) Noise budget (Example for the 16QAM 156Mbps system)

(a) Example of noise budget allocating mostly on interference



(b) Example of noise budget allocating mostly on thermal noise



(Note) In discussing interference with a different operator, it is preferable to use the budgeted value described in the Example of (a).

(C) Conditions for calculation

Parameters of radio equipment

Frequency	22, 26, 38 GHz bands
Transmitter power	+12 dBm, +20 dBm, +27 dBm (output at the terminal for antenna)
Equivalent noise bandwidth	52.5 MHz (156Mbps/16QAM), 17.5 MHz (52Mbps/16QAM)
Noise figure	8 dB (22/26 GHz band), 10 dB (38 GHz band)
FEC	Available (single error correction)
Link unavailability caused by rainfall	0.004 %/year, 0.0004 %/year
Antenna gain	38 dBi (22 GHz band), 39 dBi (26 GHz band), 44 dBi (38 GHz band) (60 cm parabolic antenna)

Rainfall intensity at 0.0075% on cumulative probability distribution of rainfall per minute 1.66 mm/minute (Tokyo)

(D) Examples of calculation

The following tables summarize maximum link distances obtained from the link design for the case of (a) in item (B). In the tables, a figure in a parenthesis represents the maximum link distance for the case of (b) in item (B).

(a) Maximum link distance for the 22 GHz band 52Mbps system

Unavailability \ Transmitter power	+12 dBm	+20 dBm	+27 dBm
0.004 %/year	3.0 km (3.3 km)	3.7 km (4.1 km)	4.4 km (4.8 km)
0.0004 %/year	1.9 km (2.1 km)	2.4 km (2.6 km)	2.8 km (3.0 km)

(b) Maximum link distance for the 22 GHz band 156Mbps system

Unavailability \ Transmitter power	+12 dBm	+20 dBm	+27 dBm
0.004 %/year	2.6 km (2.9 km)	3.3 km (3.6 km)	3.9 km (4.3 km)
0.0004 %/year	1.7 km (1.9 km)	2.1 km (2.3 km)	2.5 km (2.7 km)

(c) Maximum link distance for the 26 GHz band 52Mbps system

Unavailability \ Transmitter power	+12 dBm	+20 dBm	+27 dBm
0.004 %/year	2.4 km (2.7 km)	3.0 km (3.2 km)	3.5 km (3.8 km)
0.0004 %/year	1.5 km (1.7 km)	1.9 km (2.0 km)	2.2 km (2.3 km)

(d) Maximum link distance for the 26 GHz band 156Mbps system

Unavailability \ Transmitter power	+12 dBm	+20 dBm	+27 dBm
0.004 %/year	2.1 km (2.3 km)	2.6 km (2.9 km)	3.1 km (3.4 km)
0.0004 %/year	1.4 km (1.5 km)	1.7 km (1.8 km)	2.0 km (2.1 km)

(e) Maximum link distance for the 38 GHz band 52Mbps system

Unavailability \ Transmitter power	+12 dBm	+20 dBm	+27 dBm
0.004 %/year	1.9 km (2.0 km)	2.2 km (2.3 km)	2.5 km (2.7 km)
0.0004 %/year	1.2 km (1.2 km)	1.4 km (1.4 km)	1.5 km (1.6 km)

(f) Maximum link distance for the 38 GHz band 156Mbps system

Unavailability \ Transmitter power	+12 dBm	+20 dBm	+27 dBm
0.004 %/year	1.7 km (1.8 km)	1.9 km (2.1 km)	2.3 km (2.4 km)
0.0004 %/year	1.1 km (1.1 km)	1.3 km (1.2 km)	1.4 km (1.5 km)

(2) Example of link design of the system with less than 52Mbps transmission rate

(A) Quality

This link design is made assuming a model case that rate exceeding BER = 10^{-4} caused by rainfall (Unavailability) is 0.004 %/year and 0.0004 %/year respectively.

(B) Noise budget

(a) Example of noise budget for the 6Mbps (QPSK) system

- BER = 1×10^{-4} Required C/N 11.8dB
  - Fixed degradation 3dB 14.8dB
    - Thermal noise 18.7dB (40.7%)
    - Interference from other systems 20.1dB (29.7%)
      - 28.4dB Satellite, etc.
      - 23.8dB Interference from own other systems
      - 23.8dB Interference from different operators' systems
        - 24.1dB One-side adjacent interference
        - 35.4dB Co-channel interference
    - Interference by same system 20.1dB (29.7%)
      - Interference from own other systems 25.4dB
        - 37.4dB Adjacent channel interference from different polarization channels
        - 35.4dB Over-reach interference
        - 26.2dB Adjacent channel interference from same polarization channels
      - Interference from different operators' systems 21.6dB Same polarization interference from different operators' systems
        - 21.7dB One-side adjacent interference
        - 35.4dB Co-channel interference

(b) Example of noise budget for the 45Mbps (4FSK) system

- BER = 1×10^{-4} Required C/N 12.8dB
  - Fixed degradation 3dB 15.8dB
    - Thermal noise 21.7dB (25.7%)
    - Interference from other systems 20.1dB (37.2%)
      - 28.4dB Satellite, etc.
      - 23.8dB Interference from own other systems
      - 23.8dB Interference from different operators' systems
        - 24.1dB One-side adjacent interference
        - 35.4dB Co-channel interference
    - Interference by same system 20.1dB (37.2%)
      - Interference from own other systems 25.4dB
        - 37.4dB Adjacent channel interference from different polarization channels
        - 35.4dB Over-reach interference
        - 26.2dB Adjacent channel interference from same polarization channels
      - Interference from different operators' systems 21.6dB Same polarization interference from different operators' systems
        - 21.7dB One-side adjacent interference
        - 35.4dB Co-channel interference

(C) Conditions for calculation

Parameters of radio equipment

Frequency	22, 26, 38 GHz bands
Transmitter power	+15 dBm, +20 dBm, +27 dBm (output at the terminal for antenna)
Equivalent noise bandwidth	4.9 MHz (6Mbps/QPSK) 25.4 MHz (45Mbps/4FSK)
Noise figure	8 dB (22/26GHz bands), 10 dB (38GHz band)
FEC	Unavailable
Link unavailability caused by rainfall	0.004 %/year, 0.0004 %/year
Antenna gain	38 dBi (22GHz band), 39 dBi (26 GHz band), 44dBi (38 GHz band) (60 cm parabolic antenna)
Rainfall intensity at 0.0075% on cumulative probability distribution of rainfall per minute	1.66 mm/minute (Tokyo)

(D) Examples of calculation

The following tables summarize maximum link distances obtained from the link design.

(a) Maximum link distance for the 22 GHz band 6Mbps (QPSK) system

Transmitter power / Unavailability	+15 dBm	+20 dBm	+27 dBm
0.004 %/year	4.4 km	5.0 km	5.7 km
0.0004 %/year	2.8 km	3.1 km	3.5 km

(b) Maximum link distance for the 22 GHz band 45Mbps (4FSK) system

Transmitter power / Unavailability	+15 dBm	+20 dBm	+27 dBm
0.004 %/year	3.4 km	3.9 km	4.6 km
0.0004 %/year	2.2 km	2.5 km	2.9 km

(c) Maximum link distance for the 26 GHz band 6Mbps (QPSK) system

Transmitter power / Unavailability	+15 dBm	+20 dBm	+27 dBm
0.004 %/year	3.5 km	3.9 km	4.4 km
0.0004 %/year	2.2 km	2.4 km	2.9 km

(d) Maximum link distance for the 26 GHz band 45Mbps (4FSK) system

Transmitter power / Unavailability	+15 dBm	+20 dBm	+27 dBm
0.004 %/year	2.7 km	3.1 km	3.6 km
0.0004 %/year	1.8 km	2.0 km	2.3 km

(e) Maximum link distance for the 38 GHz band 6Mbps (QPSK) system

Transmitter power / Unavailability	+15 dBm	+20 dBm	+27 dBm
0.004 %/year	2.5 km	2.7 km	3.0 km
0.0004 %/year	1.5 km	1.7 km	1.9 km

(f) Maximum link distance for the 38 GHz band 45Mbps (4FSK) system

Transmitter power / Unavailability	+15 dBm	+20 dBm	+27 dBm
0.004 %/year	2.2 km	2.4 km	2.7 km
0.0004 %/year	1.4 km	1.5 km	1.7 km

Appendix-3 Conditions for Coexistence of P-P System and P-MP System

Study result of conditions for coexistence of P-P system and P-MP 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-3.1
Interfering station:	P-P system	
	Technical Specification	Table A-3.2
	Spectral characteristics	Figure A-3.3

To keep equal to or lower than the allocated C/N (or C/I) for interference from other operators' systems shown in Table A-3.1, 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: Differential 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 : wavelength [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]

The IRF value calculation considering the calculation model specification for the P-MP system shown in Table A-3.1 and the spectral characteristics of the P-P system shown in Figure A-3.3 is resulted as Figure A-3.4. As the figure shows, the IRF values obtained vary greatly depending on the transmission rate, 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-3.2
Interfering station:	P-MP system	
	Technical Specification	Table A-3.1
	Spectral characteristics	Figure A-3.1 and A-3.2

To keep equal to or lower than the allocated C/N (or C/I) value for interference from other operator' systems shown in Table A-3.2, the carrier to interference noise power ratio C/Nmp must satisfy:

$C/Nmp \geq 28.7$ 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/U can be obtained using the following equation:

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

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-3.5 and A-3.6. As these figures show, the values obtained vary markedly depending on the transmission rate.

(3) Example of calculation

As an example, the relationship between the interference wave path length and the interference wave suppression (dB) is shown in Figure A-3.7.

Technical Specification of	P-MP system	Table A-3.1
Technical Specification of	P-P system	Table A-3.2

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.

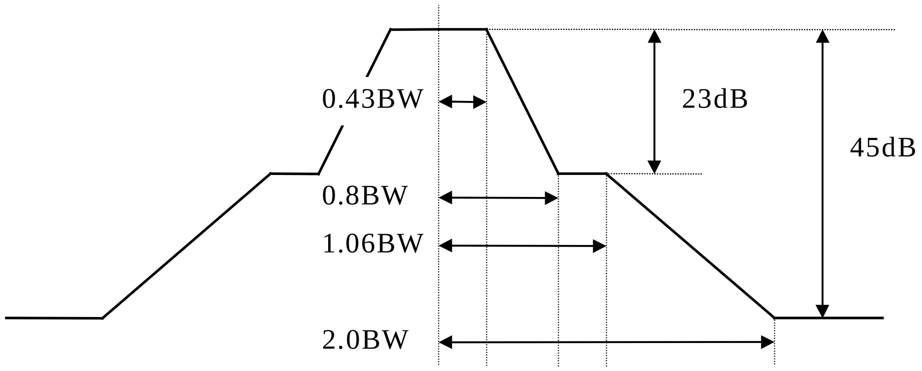


Figure A-3.1 Example of P-MP system spectrum (TDMA)

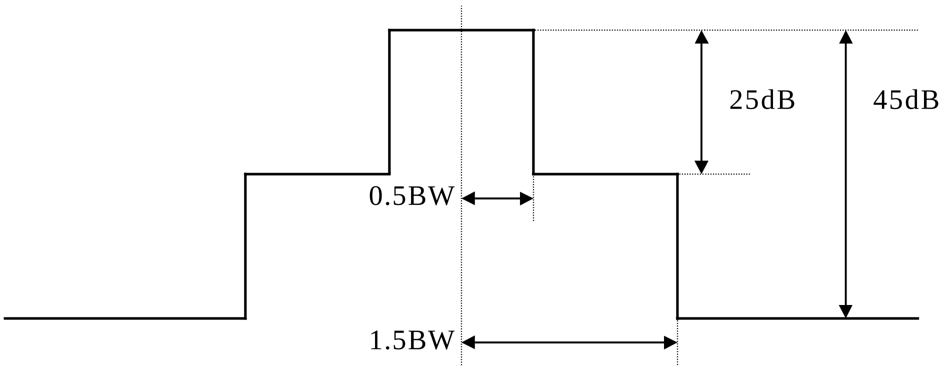


Figure A-3.2 Example of P-MP system spectrum (FDMA)

Table A-3.1 Specification of a P-MP system used for calculation model

(a) Base station specification

Item	Specification
Modulation method	QPSK
Antenna gain	16 dBi
Feeder loss	2 dB
Transmitter power	22.0 dBm
Receiver input level (clear air)	–58.6 dBm
Symbol rate	16 Msymbol/sec
Channel spacing	24 MHz
Receiving filter	Equal split square root 50% roll-off filter Out of band attenuation 40 dB
C/N allocated for interference from different operator's system	25.4 dB

(b) Subscriber station specification

Item	Specification
Modulation method	QPSK
Antenna gain	33 dBi
Feeder loss	0 dB
Transmitter power	22.0 dBm
Receiver input level (clear air)	–58.6 dBm
Symbol rate	16 Msymbol/sec
Channel spacing	24 MHz
Receiving filter	Equal split square root 50% roll-off filter Out of band attenuation 40 dB
C/N allocated for interference from different operator's system	23.4 dB

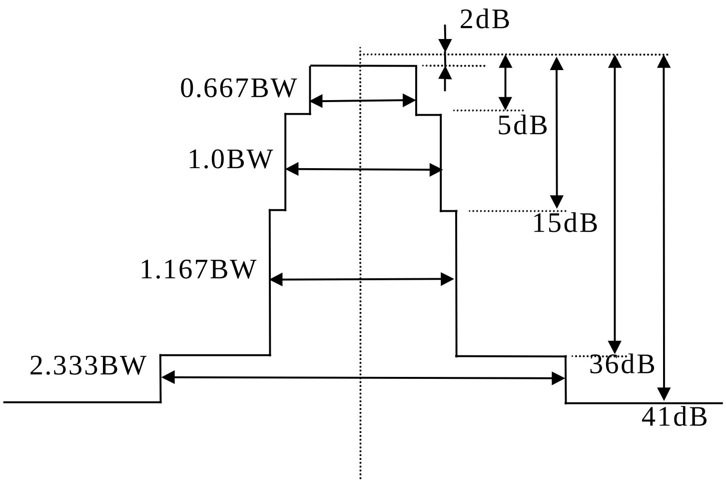


Figure A-3.3 Example of 156Mbps 16QAM P-P System Spectrum

Table A-3.2 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)	−33dBm
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 operator’s system	28.7 dB

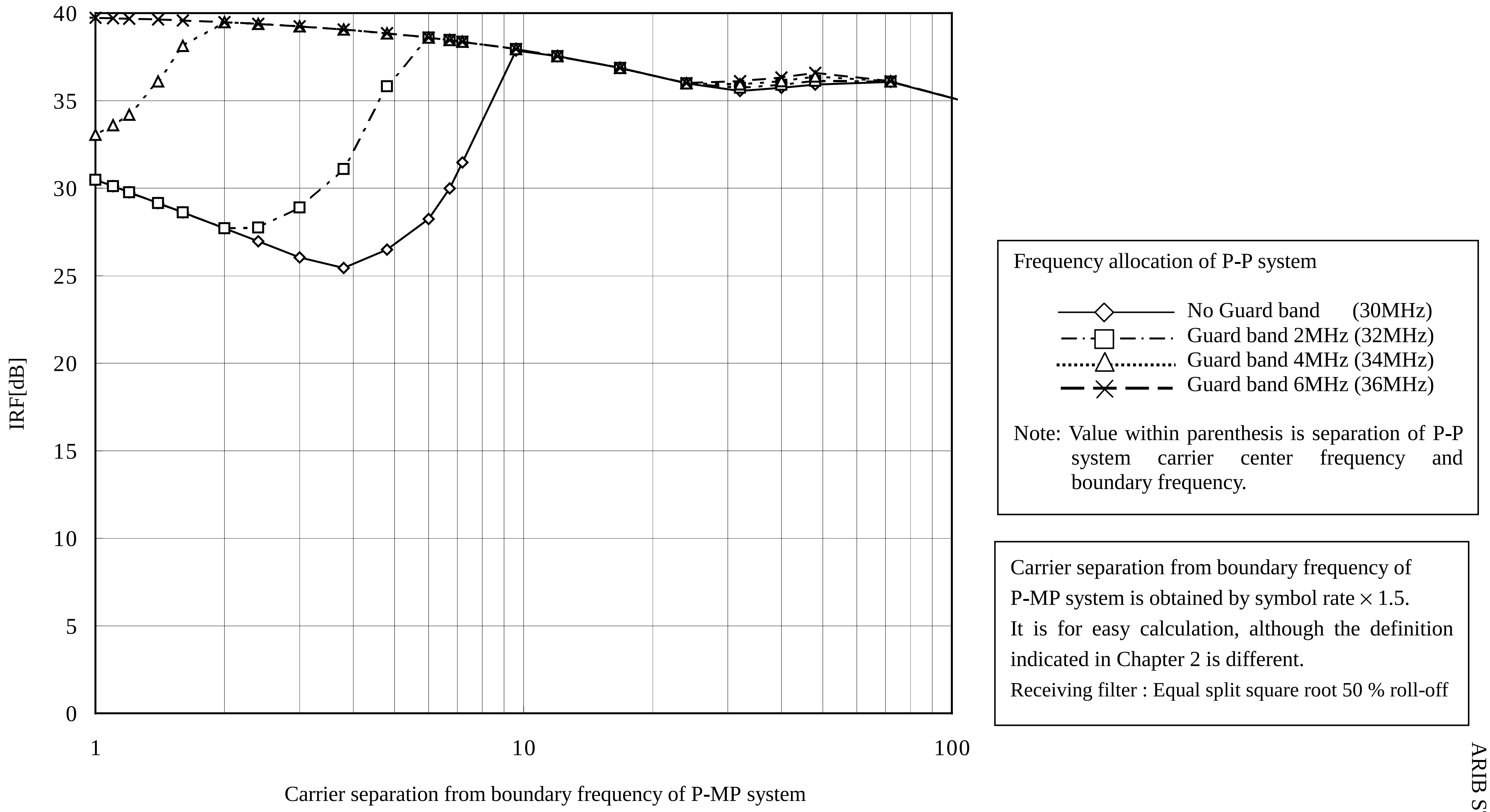
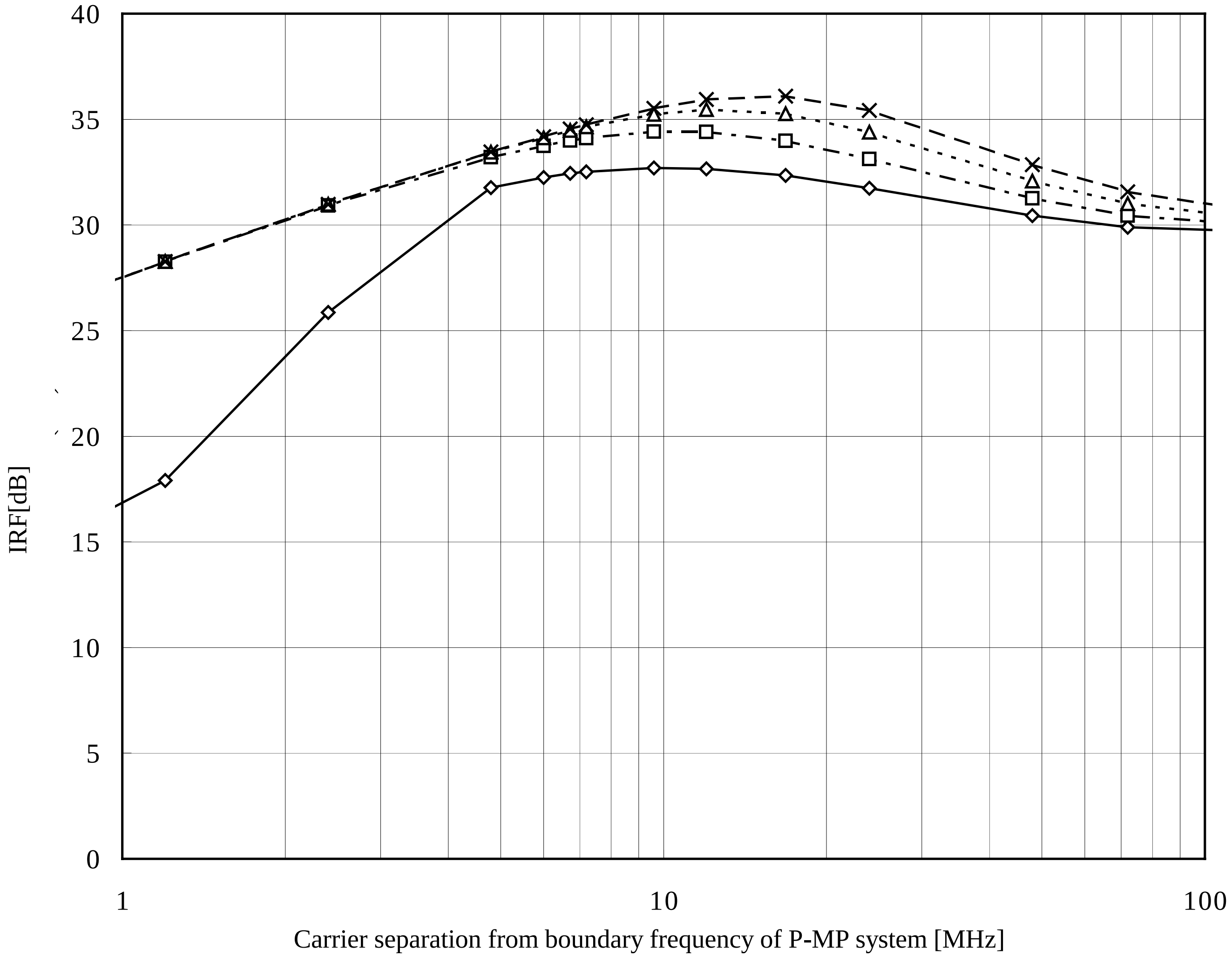


Figure A-3.4 IRF value for the P-P system (Table A-3.2) to the P-MP system (Table A-3.1) interference



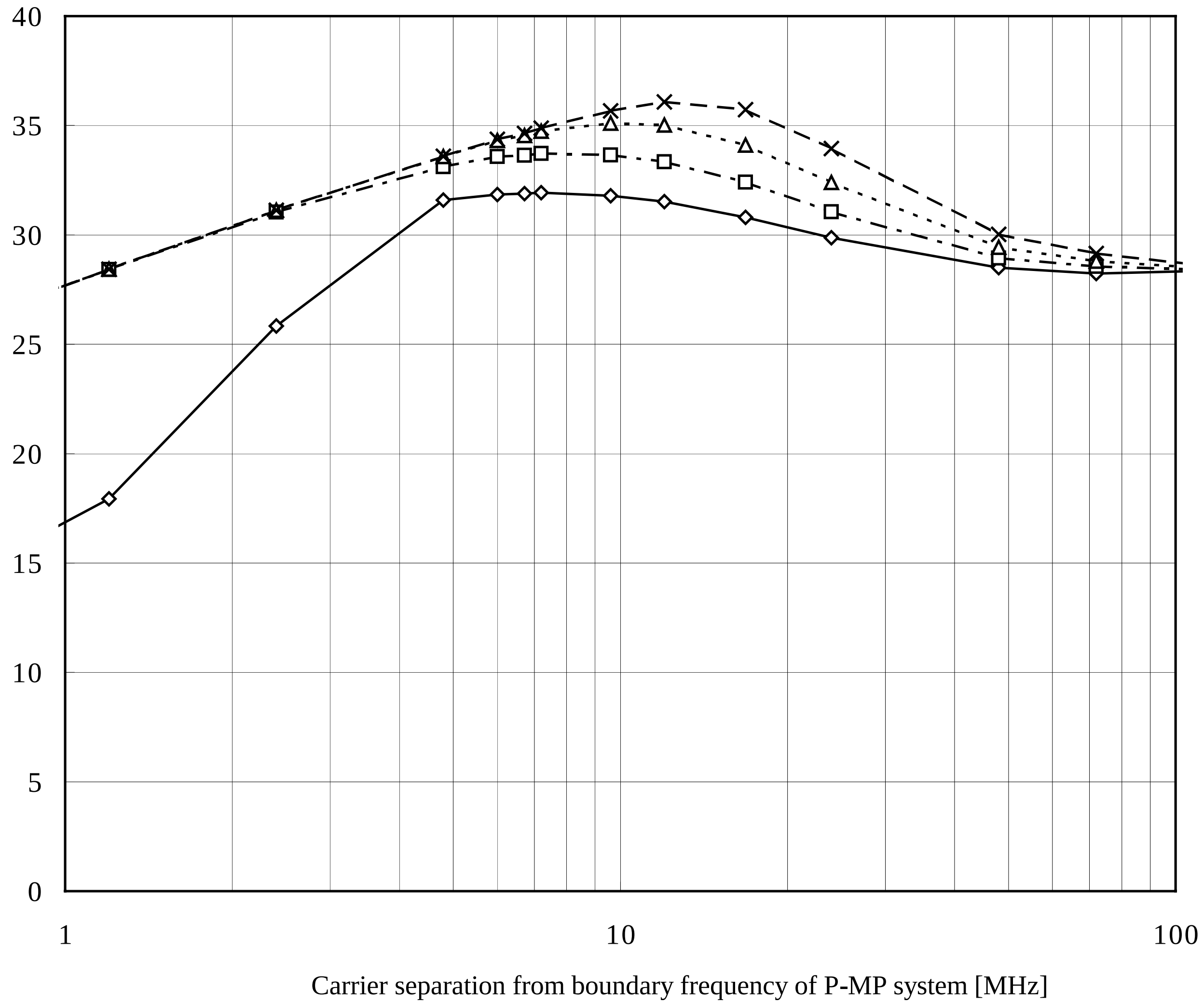
Frequency allocation of P-P system

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-3.5 IRF value for the P-MP TDMA system (Table A-3.1) to the P-P system (Table A-3.2) interference



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-3.6 IRF value for the P-MP FDMA system (Table A-3.1) to the P-P system (Table A-3.2) interference

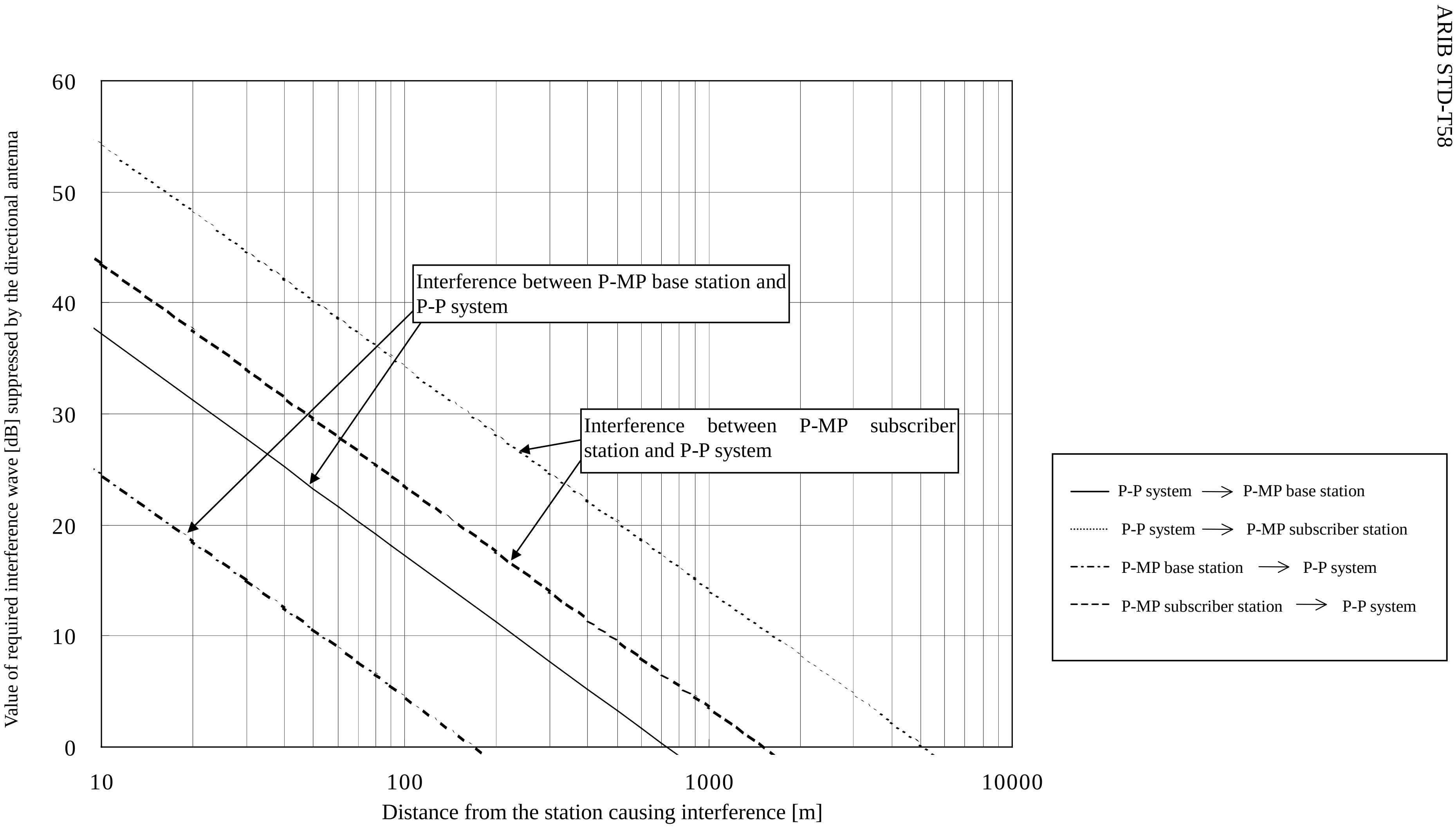


Figure A-3.7 Interference wave path length and interference wave suppression by the directivity of antennas used for the P-MP TDMA system(Table A-3.1) and the P-P system(Table A-3.2)

Appendix-4　Permissible Interference Level and Required Separation Distance in the Same Frequency Block

(1)　Permissible interference level from the different operator using the same frequency block
More than two operators sometimes share the same frequency block from the standpoint of efficient frequency usage. Table A-4.1 shows permissible interference wave level for various modulation methods under the normal conditions based on the example of noise budget shown in Appendix-2.

Table A-4.1　Permissible Interference level from the Different Operator Using the Same Block

Modulation method	Allocated C/N for interference from radio station of different operator
Quadrature Phase Shift Keying	35.4 dB
4-state Frequency Shift Keying	35.4 dB
16-level, 32-level, or 64-level Quadrature Amplitude Modulation	40.0 dB

The values shown in the above Table should be used as a reference to judge the interference from the newly installed radio station to the existing radio station of the different operator and used as the basis for coordination between operators.
The permissible interference that the newly installed radio station receives from the existing radio station shall be set up on the newly installed radio station side considering the radio link quality required for telecommunication service.

(2)　Example of calculation for required separation distance in the same frequency block
Sample calculation result of the required separation distance between interfering station and interfered station to avoid interference from different operator using the same frequency block is given below.

(A)　Same block interference model
Under the condition that the interfering station directly facing the interfered station, Table A-4.2 and Figure A-4.1 respectively assumed parameters and a model.

Table A-4.2　Same Block Interference Model Parameters

Transmitter Power	+18 dBm
Frequency band	22GHz band
Antenna gain	38 dBi
Receiver input level	–33 dBm
Modulation method	16-level quadrature amplitude modulation

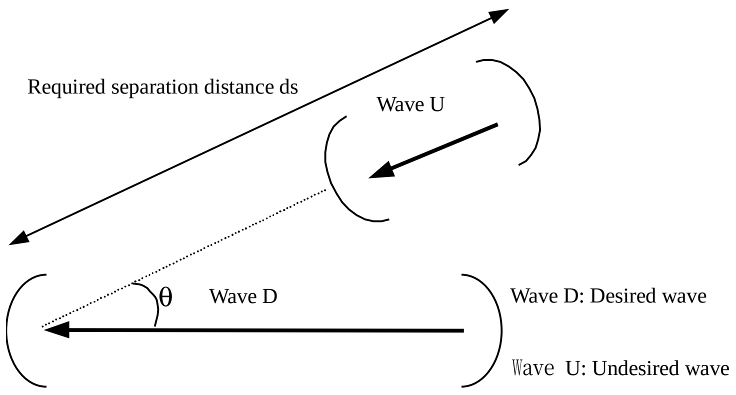


Figure A-4.1　Same Block Interference Model

(3) Line-of-sight distance

The required separation distance never exceeds the line-of-sight distance. The line-of-sight distance assuming the spherical earth is shown in Table A-4.3.

Table A-4.3 Line-of-sight Distance Assuming Spherical Earth

Station height [m]	10	20	30	40
Line-of-sight distance [km]	26.5	37	45.2	54

(4) Example of calculation of required separation distance

Table A-4.4 shows the result of calculation of the required separation distance to satisfy the following equation by using the EIRP mask value of the Transmitter antenna characteristics described in Item 2.4 (1) in Chapter 2. In this case, however, the upper limit of the interference distance should be the line-of-sight distance. Also, it should be noted that DRA is not considered in this calculation.

D/U = PRD − PRU

PRU = PTU – L – A(θ) + 2G

D/U : D/U on Interference from different Carrier [dB]

PRD : Receiver input level [dBm] (–33 dBm)

PRU : U wave receiver input level[dBm]

PTU : U wave transmitter power [dBm] (+18 dBm)

L : U wave free space propagation loss [dB]

A(θ) : Antenna directivity attenuation on U wave [dB]

G : Antenna gain [dBi] (38 dBi)

Table A-4.4 Calculation Result of Minimum Required Separation Distance

Deviation θ [deg]	Required Separation Distance ds [km]
0	238
1	153
2	99
3	64
4	41
5	27

Deviation θ [deg]	Required Separation Distance ds [km]
10	13
20	6.3
40	3.1
90	1.3
180	1.2

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