

## SECTION 3

### ALLOCATIONS AND CRITERIA

#### GENERAL

The spectrum usage and the types of services allocated in the 2025-2300 MHz frequency range were among the key factors that had to be considered in the determination of pfd limits. A brief review of the National and International Tables of Frequency Allocations will be given in this section in order to highlight the different types of services which have allocations in the 2025-2300 MHz frequency range. A careful examination of these services and their implementation both within, and to some extent, outside the United States are discussed in this section. An understanding of such implementation is essential in the determination of pfd limits in the 2025-2300 MHz frequency range. The existing pfd limits and criteria used in their derivation will also be discussed in this section.

#### ALLOCATIONS AND ASSIGNMENTS

Internationally, the frequency range 2025-2300 MHz, shown in Table 1, is allocated to Fixed and Mobile Services with the exception of the last 10 MHz (2290-2300 MHz) which is allocated to Space Research (deep space) and Fixed Services. Footnotes 747, 748, and 750 permit Space Research, Earth Exploration Satellite, and Space Operations Services in the 2025-2110 MHz worldwide. A majority of the ITU member administrations use the International Table of Allocations as their national table of frequency allocations. A majority of the countries in Region 2 are among these administrations.

For these administrations, the frequency band 1710-2300 MHz (590 MHz) is allocated to systems in the Fixed Service. However, despite the availability of more spectrum, the use of this frequency range varies from one country to another depending upon the Government structures. In some countries like Brazil, Argentina, Canada, and Mexico frequency planning is necessary and yet there are others where extensive band planning is not that critical. Information on the use of this frequency range is scarce and sometimes not accurate for the majority of these and other countries in Region 2, except the United States and Canada. Excerpts from the ITU File shown in Table 2 show the number of assignments recorded by the International Frequency Registration Board (IFRB). This ITU File is updated once a year and the member administrations are not required to register their frequency assignments for every system with the IFRB. Marketing information received from the U.S manufacturers indicates that the equipment sold in this frequency range to the countries in South and Central America as well as Canada are similar in characteristics as those used in the United States. If similarity of equipment characteristics may be used as a measure of the band usage, it may be stated that at least in Region 2 the proliferation of high capacity systems with large tuning range such as those used in the 4 and 6 GHz communication bands is not likely to occur in the above noted frequency range. As a result, one may state that even though spectrum for the Fixed Service is made available by the ITU, the typical usage by the systems similar in characteristics to those used in the United States dominates the frequency range. A survey made by the European Space Agency indicated that in Europe some "long-haul" communications exist in the Fixed Service in this frequency

TABLE 1

EXCERPTS FROM THE INTERNATIONAL TABLE OF FREQUENCY ALLOCATIONS  
(1710-2300 MHz)

**MHz**  
**1 710 — 2 290**

Allocation to Services		
Region 1	Region 2	Region 3
<b>1 710 — 2 290</b>	<b>1 710 — 2 290</b>	
<b>FIXED</b>	<b>FIXED</b>	
<b>Mobile</b>	<b>MOBILE</b>	
722 744 746 747 748 750	722 744 745 746 747 748 749 750	
<b>2 290 — 2 300</b>	<b>2 290 — 2 300</b>	
<b>FIXED</b>	<b>FIXED</b>	
<b>SPACE RESEARCH</b> (deep space) (space-to-Earth)	<b>MOBILE except aeronautical mobile</b>	
<b>Mobile except</b> <b>aeronautical mobile</b>	<b>SPACE RESEARCH (deep space)</b> (space-to-Earth)	

Footnotes applicable to the analysis in this report

- 747 Subject to agreement obtained under the procedure set forth in Article 14, the band 2 025 — 2 110 MHz may also be used for Earth-to-space and space-to-space transmissions in the space research, space operation and earth exploration-satellite services. The services using space-to-space transmissions shall operate in accordance with the provisions of Nos. 2557 to 2560 and shall not cause harmful interference to the other space services.
- 748 Subject to agreement obtained under the procedure set forth in Article 14, the band 2 110 — 2 120 MHz may also be used for Earth-to-space transmissions in the space research (deep space) service.
- 750 Subject to agreement obtained under the procedure set forth in Article 14, the band 2 200 — 2 290 MHz may also be used for space-to-Earth and space-to-space transmissions in the space research, space operations and earth exploration-satellite services. These services shall operate in accordance with the provisions of Nos. 2557 to 2560; the space-to-space transmissions shall not cause harmful interference to the other space services.

TABLE 2. EXCERPTS FROM THE INTERNATIONAL  
 FREQUENCY REGISTRATION BOARD FILE.  
 (2025-2300 MHz)

NAME OF COUNTRY	NO. OF ASSIGNMENT
Argentina	169
Bahamas	2
Dominican Republic	1
Guatemala	41
Greenland	14
Guyana	22
British West Indies	6
Mexico	393
Martinique	29
Republic of Panama	1
Paraguay	12
Puerto Rico	13
Uruguay	8
Canada	198
Panama Zone	2
<b>TOTAL</b>	<b>911</b>

range. But the term "long-haul" in Europe compared with the geographical boundaries could imply any microwave transmission no further than a few hundred miles.

Generally, in the United States the allocation table for the frequency range 2025-2300 MHz is planned to be responsive to higher demand on spectrum. The Canadian Department of Communication has made an attempt to bring a greater agreement between the U.S. planning of the 2025-2300 MHz frequency range and that which is used in Canada. Similar statements may be made about Mexico. A U.S. marketing office involved in the sale of 2 GHz equipment to Latin American countries stated that industrial use of the spectrum in the 1710-2300 MHz frequency band has been the trend so far. The sketchy description of the use of the frequency band internationally leads to no general conclusions except that the determination of the international usage of the band is complex and that from the equipment point of view the band usage may follow that which has been adopted by the United States.

The U.S. frequency-range planning referred to above is shown in Figure 1. Note that the non-Government portion of the frequency range, 2025-2300 MHz, has been divided by the FCC for use by different station classes defined by the FCC Rules and Regulations. This usage, which impacts the assumptions used in the computation of pfd limits, are discussed below.

The FCC divided the 175 MHz non-government band, which spans the frequency range 2025-2200 MHz, into two parts. The first part is 85 MHz wide beginning at 2025 MHz and is for use by the Auxiliary Broadcast Station which is described in part 74 of the FCC Rules and Regulations (Code of Federal Regulations: 47CFR74.601). Classes of Television Auxiliary Broadcast Stations presently defined by these regulations are as follows:

"(a) TV pickup station. A land mobile station used for the transmission of television program material and related communications from the scenes of events occurring at points removed from the station studios to TV broadcast and low power TV stations.

(b) TV STL station (studio-transmitter link). A fixed station used for the transmission of television program material and related communications from the studio to the transmitter of a TV broadcast or low power TV station.

(c) TV intercity relay station. A fixed station used for intercity transmission of television program material and related communications for use by TV broadcast and low power TV stations.

(d) TV translator relay station. A fixed station used for relaying programs and signals of TV broadcast stations to LPTV, TV translator, and other communications facilities that the FCC may authorize."

These stations in the Auxiliary Broadcast, may be fixed or mobile. It should be pointed out that these systems have no more than several channels and are not used for transmission of information (voice and picture) beyond several repeater stations.

UNITED STATES TABLE		FCC USE DESIGNATORS	
GOVERNMENT	NON-GOVERNMENT	RULE PART(s)	Special-Use Frequencies
Allocation MHz (4)	Allocation MHz (5)	(6)	(7)
1 990 - 2 110  US90 US111 US219 US222	1 990 - 2 110  FIXED MOBILE  US90 US111 US219 US222 NG23 NG118	AUXILIARY BROADCASTING (74)	
2 110 - 2 200  US111 US219 US222 US252	2 110 - 2 200  FIXED  US111 US219 US222 US252 NG23	DOMESTIC PUBLIC FIXED (21) PRIVATE OPERATIONAL-FIXED MICROWAVE (94)	
2 200 - 2 290  FIXED MOBILE SPACE RESEARCH (space-to-Earth) (space-to-space)  G101	2 200 - 2 290		
2 290 - 2 300  FIXED MOBILE except aero- nautical mobile SPACE RESEARCH (space-to-Earth) (deep space only)	2 290 - 2 300  SPACE RESEARCH (space-to-Earth) (deep space only)		

Figure 1: Excerpts from NTIA Allocation Table and FCC Rules and Regulations

Footnotes for Figure 1 are given on the next page

Footnotes from Figure 1:

**G101**—In the band 2200–2290 MHz, space operations (Space-to-Earth) and (Space-to-space), and earth exploration-satellite (Space-to-Earth) and (Space-to-space) services, may be accommodated on a co-equal basis with fixed, mobile and space research service.

**US90**—In the band 2025–2110 MHz earth-to-space and space-to-space transmissions may be authorized in the space research and earth exploration-satellite services subject to such conditions as may be applied on a case-by-case basis. Such transmissions shall not cause harmful interference to non-Government stations operating in accordance with the Table of Frequency Allocations. All space-to-space transmission reaching the earth's surface shall adhere to a power flux density of between  $-144$  and  $-154$  dbw/M<sup>2</sup>/4 kHz depending on the angle of arrival per ITU Radio Regulation 2557 and shall not cause harmful interference to the other space services.

**US252**—The bands 2110–2120 and 7145–7190 MHz, 34.2–34.7 GHz are also allocated for earth-to-space transmissions in the Space Research Service, limited to deep space communications at Goldstone, California.

The second part of the non-Government band in the 2025-2300 MHz frequency range is 90 MHz wide starting with 2110 MHz and is divided into four bands for use by two different services as shown in Figure 1. These services are Domestic Public and Private Operational Fixed Microwave. These two have been allocated two non-adjacent segments of the spectrum which separate the transmitter and receiver frequencies at any given site. This point is discussed in more detail in the analysis section of the report.

The operation and licensing requirements for the systems in the Fixed Service, that operate in various segments of the 90 MHz, are given in the FCC Rules and Regulations (94CFR 94.61 and 21CFR). Generally, the licensing requirements and compliance with the FCC Rules and Regulations make it necessary for these systems to be operationally narrow band with a limited number of repeaters. As a result, it is unlikely for the 2025-2200 MHz non-Government use to expand in the United States in the manner which presently exists in the communication bands near 4 and 6 GHz.

A review of the allocations in the 2025-2120 MHz frequency range is important. The three space services in Figure 1 are permitted by footnote to operate in the 2025-2110 MHz frequency range. These services are: Space Research, Space Operation, and Earth Exploration Satellite. These services share the frequency range allocated to non-Government users shown in Figure 1. The non-Government users are Auxiliary Broadcast and Domestic Public. Systems in the Auxiliary Broadcast, in general, consist of a few hops and are narrow band. The deep space Earth-to-space transmission in the 2110-2120 MHz frequency range is authorized by Footnote US252. Hence, systems in the Domestic Public are not affected by the Space Services in the non-Government portion of the desired frequency range.

The above discussion on the allocations and usage in the 2025-2300 MHz frequency range indicates that:

1. The 2025-2300 MHz frequency range planning in the United States is different from that in other countries.
2. Because of the spectrum planning described above, the spectrum is more for commercial applications and, so far, systems such as those in 4 and 6 GHz communication bands have not been developed for this frequency range. For example, FCC has allocated 120 MHz (1990-2110) to Auxiliary Broadcast which by CCIR definition is not a long-haul communication system. Lesser spectrum, only 100 MHz (2200-2300), is allocated to Fixed and Mobile Services in the Government portion of the frequency range.
3. The pfd limits in the 2025-2300 MHz should be determined in a manner to protect the systems in the Auxiliary Broadcast operating in the 2025-2110 MHz and the systems in the Fixed and Mobile Service in the 2200-2290 MHz frequency range.
4. In Region 2, which includes the United States, the band usage varies according to economic condition and the spectrum allocations for the countries in this region. Generally speaking, Fixed and Mobile Services have more spectrum available to them in countries other than the United States.

## SUMMARY OF INTERFERENCE CRITERIA

The following discussion of the interference criteria applicable to the pfd analysis is based on CCIR Recommendations 393-3 and 357-3. The interference criteria given in these recommendation and used in the calculations of pfd are for analog systems in the Fixed Service. The criteria given by the CCIR are applicable to a Hypothetical Reference Circuit (HRC) defined in CCIR Recommendation 390-3. HRC is a necessary element in the study of certain characteristics of long-distance circuits. Operational circuits may be shorter or longer than the HRC defined by the CCIR. In practice the HRC was intended only as a guide in the planning of carrier systems in the Fixed Service. The HRC used by the CCIR in establishing the noise due to interference from satellites to a system in the Fixed Service represents a trendline 2500 km long consisting of fifty equal hops. Thus far, the criteria for noise power from satellites set forth by the CCIR pertain to the protection of analog systems using FDM/FM modulation. The criteria for the protection of digital systems have been under study and the CCIR has not yet recommended a criteria for the protection of digital systems used in the Fixed Service.

### Analog Systems (Line-of-Sight)

The noise due to interference from satellites is equal to a fraction of the total allowable noise power in a HRC. One of the objectives of noise power limits, set by the CCIR for radio-relay systems, was to have comparable noise power for both radio and cable systems. The maximum allowable noise in a HRC is given in CCIR Recommendation 393-3. This recommendation defines the maximum allowable noise power as follows:

"1. that the noise power at a point of zero relative level in any telephone channel on a 2500 km hypothetical reference circuit for frequency-division multiplex radio-relay systems should not exceed the values given below, which have been chosen to take account of fading:

1.1 7500 pWOp, psophometrically-weighted one-minute mean power for more than 20 percent of any month;

1.2 47,500 pWOp, psophometrically-weighted one-minute power for more than 0.1 percent of any month;

1.3 1,000,000 pWOp, unweighted (with an integrating time of 5 ms) for more than 0.01 percent of any month;

2. that in a part of the hypothetical reference circuit consisting of one or more of the homogeneous sections defined in Recommendation 392, the one-minute mean noise power not exceeded for 20 percent of the month shall be considered to be proportional to the number of sections involved."

It should be pointed out that the CCITT allows 2500 pWOp mean value for the frequency-division multiplex equipment in a Hypothetical Reference Circuit and this noise power is not included in the noise levels given above. A graphical presentation of the above noise levels is given in Figure 2. The

circled points on the graph are the noise levels given by the CCIR. The interpolation between these points follow an example of possible interpolation used by the CCIR in Recommendations 357-3 and 356-4. Recommendation 357-3 defines the maximum noise power levels allowable from satellites in the Fixed Satellite Service to a radio-relay system using line-of-sight transmission.

The following excerpt from Recommendation 357-3 is important to the analysis of the pfd limits given in this report:

"1. that systems in the Fixed Satellite Service and line-of-sight analogue angle-modulated radio-relay systems which share the same frequency bands, should be designed in such a manner, that in any telephone channel of a 2500 km channel Hypothetical Reference Circuit for frequency-division multiplex analogue angle-modulated radio-relay systems, the interference noise power at a point of zero relative level, caused by the aggregate of the emission of Earth stations and space stations of the systems in the Fixed Satellite Service, including associated telemetering, telecommand and tracking transmitter, should not exceed:

1.1 1000 pWOp psophometrically-weighted one-minute mean power for more than 20 percent of any month;

1.2 50 000 pWOp psophometrically-weighted one-minute mean power for more than 0.01 percent of any month.

2. that the following Note should be regarded as part of the Recommendation.

Note -- The way in which the above values are to be taken into account in the general noise objective for radio-relay systems is defined in Recommendation 393-3."

The two circled points in the lower curve in Figure 2 show the noise levels set by the CCIR in Recommendation 357-3. The distribution of noise between the two points follows from the example of possible interpolation given by the CCIR in Recommendation 357-3. This pattern of distribution by the CCIR is not unique to Recommendation 357-3. This same distribution was also used in Recommendation 356-4 which pertains to the maximum allowable interference from line-of-sight radio-relay systems to a telephone channel of a system in the Fixed Satellite Service employing frequency modulation when both systems share the same frequency bands.

The pfd limits which were adopted by the CCIR were derived using 1000 pWOp noise power level given in Recommendation 357-3. These limits in the 2025-2300 MHz frequency range are included in Section IV, Article 28, of the ITU Radio Regulations, Edition 1982.

Provisions in Nos. 2556-2559, which are applicable to line-of-sight systems in the 2025-2300 MHz frequency range, are reproduced here for easy reference.

PERCENTAGE OF ANY MONTH

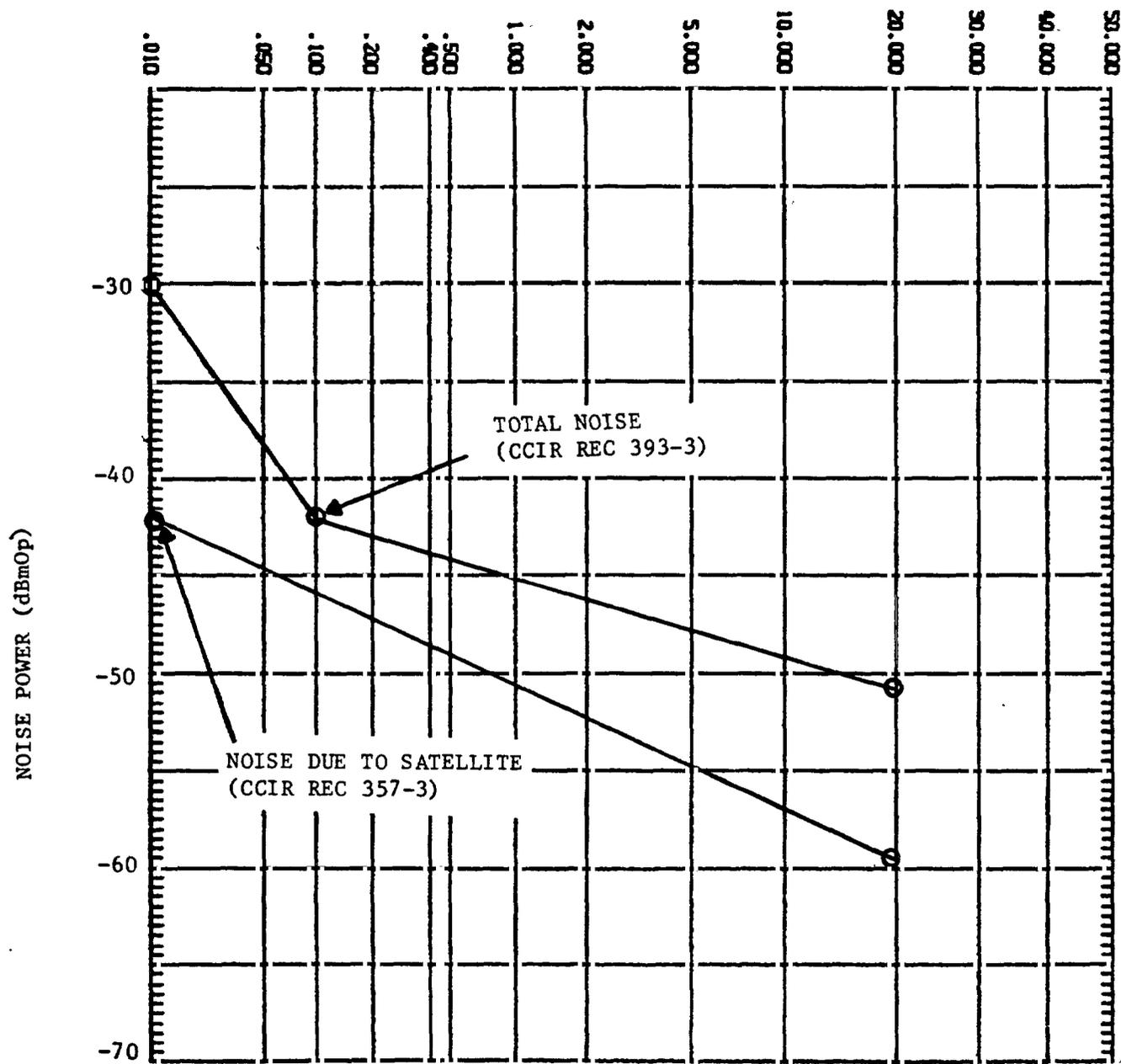


Figure 2. A Plot of CCIR Noise Power Level Criteria.

2556 (2) Power flux density limits between 1525 MHz and 2500 MHz.

2557 (a) The power flux density at the Earth's surface produced by emissions from a space station, including emissions from reflecting satellites, for all conditions and for all methods of modulation, shall not exceed the following values:

-154 dB(W/m<sup>2</sup>) in any 4 kHz band for angles of arrival between 0 and 5 degrees above the horizontal plane;

-154 + 0.5(δ-5)dB(W/m<sup>2</sup>) in any 4 kHz band for angles of arrival δ (in degrees) between 5 degrees and 25 degrees above the horizontal plane.

-144 dB(W/m<sup>2</sup>) in any 4 kHz band for angles of arrival between 25 and 90 degrees above the horizontal plane.

These limits relate to the power flux density which would be obtained under assumed free-space propagation conditions.

2558 (b) The limits given in No. 2557 apply in the frequency bands listed in No. 2559 which are allocated to the following space radiocommunication services:

- meteorological-satellite service (space-to-Earth)
- space research service (space-to-Earth)
- space operation service (space-to-Earth)

for transmission by space stations where these bands are shared with equal rights with the Fixed or Mobile Service.

2559	1525 - 1530 MHz	(for Regions 1 and 3)
	1530 - 1535 MHz	(for Regions 1 and 3, up to January 1990)
	1670 - 1690 MHz	
	1690 - 1700 MHz	(on the territory of the countries mentioned in Nos. 740 and 741)
	1700 - 1710 MHz	
	2290 - 2300 MHz	

In addition to the frequency ranges given in No. 2559, the pfd limits given in 2557 are applicable to transmissions from satellites in the 2025-2110 MHz and 2200-2290 MHz frequency ranges by Footnotes 747 and 750 of the International Table of Frequency Allocations.

The pfd limits given in the ITU Radio Regulations have been adopted by the United States and are now in Chapter 8 of the NTIA Manual. Neither ITU Radio Regulations nor the NTIA Manual make a distinction between the satellites in geostationary and non-geostationary orbits. Hence, the pfd limits noted above have been used to determine the compliance of any satellite emission on the surface of the Earth.

## Analog System (Troposcatter)

Tropospheric scatter propagation is in use outside the United States in the 2025-2300 MHz frequency range. Systems designed to use this mode of propagation are recommended to conform to appropriate CCIR Recommendation noise power levels set by the CCIR for these systems. Definition of Hypothetical Reference Circuit for transhorizon radio-relay systems and their noise power criteria are given in Recommendations 396-1 and 397-3. Extracts from Recommendation 397-3 were given in Part 1 of this report (Farrar, 1982) and are reproduced here.

CCIR distinguishes between two classes of troposcatter systems:

Class I. Systems operating between points capable of linkage by line-of-sight radio-relay or underground cable without excessive difficulty.

Class II. Systems operating under conditions precluding alternative means of communication.

The authorized noise power allowances extracted from CCIR Recommendations 397-3 and 393-3 for a CCIR hypothetical reference circuit for the two classes are given in Table 3.

According to CCIR Recommendation 397-3, Class II systems in which the noise power levels are in agreement only with the level given for 20 percent and 0.5 percent of any month are excluded from the main international and intercontinental routes. As a result, in a worldwide connection a maximum of one or two circuits of medium length will be encountered which comply with the noise power level allowed for 0.05 percent of any month.

The noise power levels indicated in Table 3 are the allowable noise power in a Hypothetical Reference Circuit for any transhorizon radio-relay system using FDM/FM modulation. Unlike the systems in line-of-sight operation, CCIR has not yet determined specific values of noise power levels from satellites for the protection of systems using troposcatter propagation. However, to protect the systems using tropospheric propagation, certain criteria have been established by the provisions in No. 2560 of the ITU Radio Regulations. Provisions in No. 2560 given below are to mitigate interference between a transhorizon radio-relay system and a satellite emitter.

2560 c) The pfd values given in No. 2557 are derived on the basis of protecting the Fixed Service using line-of-sight techniques. Where a Fixed Service using tropospheric scatter operates in the bands listed in No. 2559, and where there is insufficient frequency separation, there must be sufficient angular separation between the direction to the space station and the direction of maximum radiation of the antenna of the receiving station of the Fixed Service using tropospheric scatter to ensure that the interference power at the receiver input of the station of the Fixed Service does not exceed -168 dBW in any 4 kHz band.

TABLE 3

ALLOWABLE NOISE POWER IN THE CCIR HYPOTHETICAL REFERENCE  
CIRCUIT FOR TELEPHONY USING FREQUENCY DIVISION MULTIPLEX

DESCRIPTION	NOISE POWER (pW)	
	CLASS I	CLASS II
One minute mean power not to exceed 20% of any month	7,500 <sup>a</sup>	25,000 <sup>a</sup>
One minute mean power not to exceed 0.1% of any month	47,500 <sup>a</sup>	
One minute mean power not to exceed 0.5% of any month		63,000 <sup>a</sup>
Power not to exceed .01% of any month	1,000,000	
Power not to exceed .05% of any month		1,000,000

a. This is CCIR psophometrically weighted noise level which reduces all uniform noise powers in a 3.6 kHz band by 2.5 dB.

In the 2025-2290 MHz frequency range, the provisions of No. 2560 are not applicable to the United States, since the Government portion of this frequency range is for line-of-sight operation only and troposcatter transmission in the non-Government portion has not been employed by industry. The compliance of the emissions of spacecraft with the limit set by these provisions is examined by the IFRB for every satellite system submitted for the ITU registration. In cases of non-compliance with this limit, the United States has not yet been required to operate such assignments on a non-interference basis. However, some of the concerned ITU member administrations have required detailed data and analysis before submitting their agreement to such assignments under Article 14 of ITU Radio Regulations.

#### Criteria For Digital Radio-Relays

On a long distance system experiencing fading, CCIR Report 378-3 indicates that the performance and design of a digital radio-relay system is partially controlled by the need not to exceed an error-rate given in CCIR Report 779 ranging from approximately  $10^{-10}$  to  $10^{-10}$  for a small percentage of time. Efforts have been made by the CCIR to recommend a unanimously agreed upon criterion for the digital systems. The noise levels from satellites to a Hypothetical Reference Circuit for digital system have not been identified as distinct from those given by the CCIR for comparable analog systems. Digital systems are relatively new and perform in an electromagnetic environment originally planned by the CCIR for the operation of their analog counterpart.

A number of papers in the CCIR treat the problem of probability of bit-error-rate for digital systems. For the protection of high-capacity terrestrial radio-relay systems employing digital modulation techniques the following Recommendations typical for digital receivers, were submitted (CCIR Doc. 4/347-E, 1981):

"...the percent of any month for which a bit error rate of  $1 \times 10^{-3}$  is exceeded should not be increased by more than 0.1.

"...the percent of any month for which a bit error rate of  $1 \times 10^{-7}$  is exceeded should not be increased by more than 0.005."

CCIR has not yet adopted definite criteria for the bit-error-rate, although there is interest for the protection of terrestrial radio-relay systems using digital modulations.