REPORT 473-5*

CHARACTERISTICS OF RECEIVING EQUIPMENT FOR THE BROADCASTING-SATELLITE SERVICE**

(Question 2/10 and 11, Study Programme 2H/10 and 11)

(1970-1974-1978-1982-1986-1990)

1. Introduction

The characteristics to be adopted for receiving equipment for broadcasting-satellite systems offer a wide range of choice. These characteristics influence the size, mass and complexity of the satellite required to provide a given quality of service because of the compromise that must be made between receiver sensitivity and the power radiated by the satellite. They themselves are affected by the broadcasting standards selected. In particular, the characteristics of the receiving equipment will depend on whether it is required to receive only television signals (with only one or with more than one, accompanying sound signal), or only sound signals, or both. The present Report gives information about the most important of these characteristics on the basis of the results presented in the documents listed in the references of this Report. Many of the contributions received relate to equipment operating in the 12 GHz frequency band.

It appears that signals broadcast from satellites could be received, not only by equipments of new design, but in some cases by existing receivers fitted with adaptive devices.

As satellite broadcasting is capable of delivering a high quality TV signal to the general public, comparable to that of the studio, it seems practicable to set a higher quality target for receivers.

A distinction should be made between installations intended for community reception and for individual reception.

2. Overall characteristics of receiving equipment [CCIR, 1982-86a, b and c]

A typical receiving system for individual reception is comprised of an antenna, a low-noise receiver front end, an indoor unit containing intermediate frequency stages, programme selector, demodulation or adaptor stages, and a television monitor or television receiver.

As an example, major target performance objectives of a composite video system for a satellite broadcasting chain and receiving equipment are shown in Table IV of Report 215.

It would seem desirable to specify the overall characteristics of receiving equipment by the figure of merit G/T, which is the ratio expressed in dB(K^{-1}), between the gain of the receiving antenna (including losses) and the total noise temperature expressed in Kelvin, referred to the point of measurement of the antenna gain. The advantage of introducing the figure of merit parameter is that it is no longer necessary to specify separately the performance of the various parts of the installation, such as the noise figure, coupling loss, antenna gain, etc. The latter parameters may then be chosen by the receiver manufacturers so as to obtain the required overall performance at lowest cost.

Two different types of figure of merit (G/T) are considered:

– the "nominal G/T" is considered as a parameter characterizing the intrinsic quality of the equipment. It can be directly obtained by measuring the on-axis gain of the antenna, the "clear-sky" antenna temperature at a given elevation angle, the total receiver noise temperature and the coupling loss. No operational margins are included. This figure of merit, widely used in fixed-satellite service earth stations, is defined in Report 390. It corresponds to the highest value of the G/T ratio and allows a qualitative comparison between different receivers;

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[*] Section 11 of this Report (*Susceptibility to certain types of interference*) should be brought to the attention of Study Group 8.

[**] It is noted that work of IEC-TC12, especially SC12A, D and G is related to receiver characteristics for satellite broadcasting.

- the "usable *G/T*" is considered as the parameter directly characterizing the in-service performance of the receiving system. It therefore takes into account operational factors such as the effects of pointing errors, ageing and the increase in sky noise temperature for a given percentage of the time. This figure may thus be used directly in a link budget. Care should be taken to specify the conditions assumed for the evaluation.

A detailed definition of the figure of merit (*G/T*) and an example of how to calculate it are given in Annex I to this Report.

Receiving equipment suitable for Japan's satellite broadcasting system is commercially produced by many manufacturers. Most receivers are constructed as stated above. Antennas used are of the offset-feed type with diameters of less than 1 m. The outdoor unit is directly connected to the primary radiator of the antenna without exception. The indoor units are mostly of an adaptor type. Some units are incorporated in the main TV receiver.

Annex II indicates preferred characteristics of satellite broadcasting receivers now being produced in Japan and their present average performance .

Annex III shows examples of characteristics for receiving equipment in Italy and also gives the signal quality obtained in a satellite bandwidth of 27 MHz.

A range of equipment has come onto the market following the launching of TDF-1 in France. The antennas used are either parabolic with diameters of 30 to 55 cm, or slightly larger flat antennas. The D2-MAC/packet decoding equipment for indoor use is either housed in a separate unit or incorporated in the television set itself.

Annex IV gives examples of the characteristics of receiving systems used for reception of TDF-1.

3. Antenna systems [CCIR, 1982-86a;]

In the 12 GHz band, a common form of antenna for individual reception is one with a conventional or offset parabolic reflector, 0.3 to 1 m in diameter. Large diameters may, however, be used for community reception. Small, flat-plate antennas are also now of interest and becoming available for direct reception. Antenna technology is discussed in Report 810.

Any antenna is subject to mispointing caused by ageing and wind pressure as well as the unavoidable pointing error referred to above. The relationship between the antenna diameter and the "usable" figure of merit was studied by taking into account the loss in gain introduced by the antenna pointing error and is indicated in Fig. 1. From this figure, it is apparent that the use of antennas larger than 1 m in diameter may have significant disadvantages if the total pointing error due to the ageing, wind pressure, and other factors which produce a deflection of about ± 1°, is taken into account. The larger the antenna diameter, the greater its mispointing under wind pressure. In addition, a large antenna requires additional space for installation.

Receiving systems using a relatively small diameter antenna are now capable of offering the figure of merit and directivity established in the 12 GHz Plans. This capability has been achieved because:

- the noise figure of the low-noise front end has been improved far below (e.g. 1.8 dB is a typical value, currently available) the level previously expected at the WARC-BS-77;
- the antenna efficiency has been enhanced from 55% to 70%; and
- the side-lobe level has been markedly reduced through the use of the offset-feed type antenna.

For example, in the case of the BS-2 in Japan with maximum satellite e.i.r.p. of about 58 dBW, 45 to 60 cm diameter antennas are generally used for home receiving equipment.

In the case of a linearly polarized system it will also be necessary to ensure correct rotational orientation, better than 2°, for example, in order to provide adequate protection against orthogonally polarized signals. From the point of view of aligning the antenna, it will be advantageous to use circular polarization. In this case, the antenna feed may be a little more complex to manufacture than if linear polarization were used.

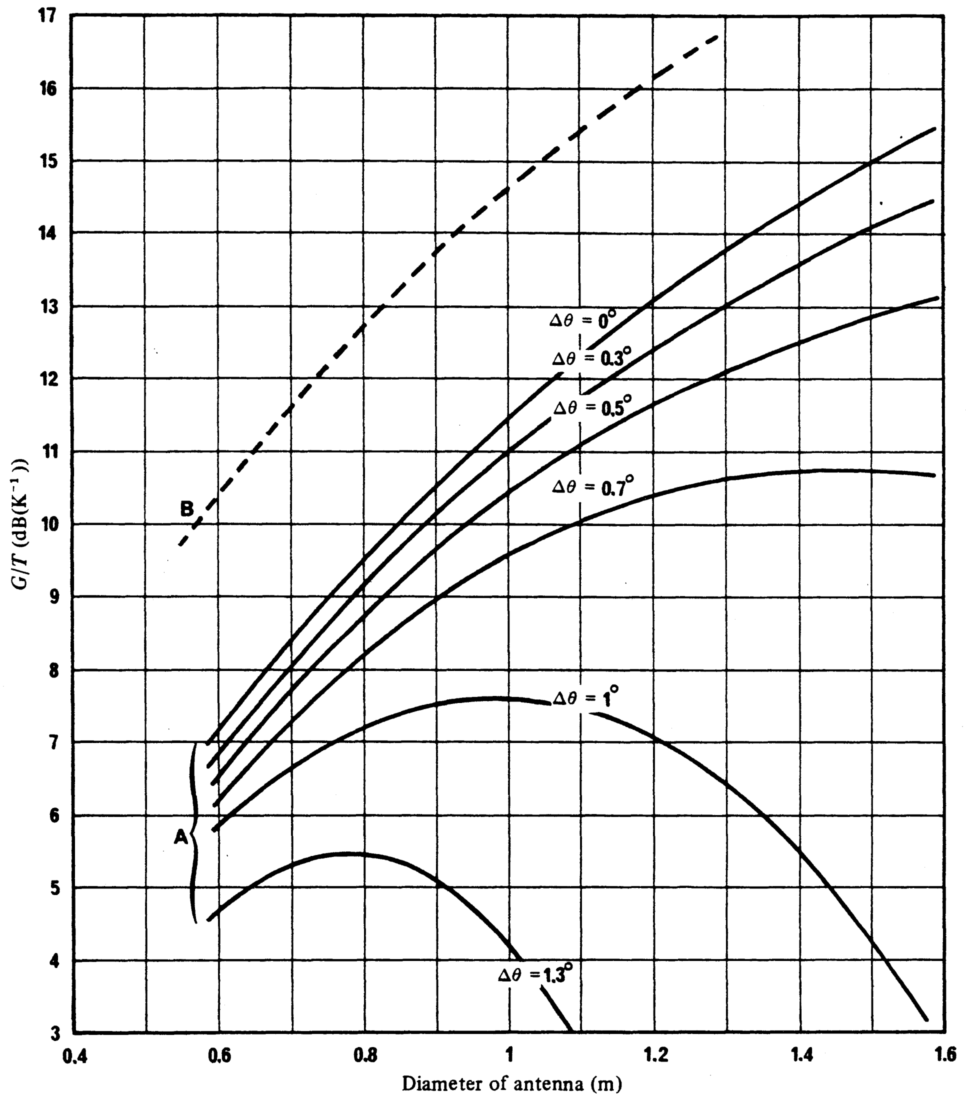


FIGURE 1 – *"Usable" figure of merit (G/T) considering various causes of pointing error*

$$G/T = \frac{\alpha\beta G_r}{\alpha T_a + (1-\alpha)\, T_0 + (n-1)\, T_0}$$ (These parameters are defined in Annex I)

where for curves A: α = 0.9

β = losses due to overall pointing error $\Delta\theta$ (see Note 1)

T_a = 150 K

T_0 = 290 K

n = 2.51 (noise figure = 4 dB)

f = 12 GHz

η = 0.6 (see Note 2)

and for curve B: α = 1

β = 1($\Delta\theta$ = 0)

n = 1.78 (noise figure = 2.5 dB)

η = 0.7

Note 1. – Overall pointing error includes positioning error of the satellite (±0.16°), setting error of the antenna (approximately 10 to 20% of the half-power beamwidth of the antenna) and additional pointing error due to wind pressure and ageing etc.

Note 2. – The effect of antenna efficiency on G/T for a given antenna diameter is given by 10 log (η/0.55) (dB), i.e., increasing the antenna efficiency from 0.55 as given in Table IV of Annex I to 0.70 will increase the G/T by 0.4 dB.

Receiving antenna diagrams for various frequency ranges are given in Report 810 indicating the upper limit of the relative gain as a function of the angle, to be assumed for planning purposes.

The choice of the feed arrangement may also be influenced by the associated feeder losses. In the 12 GHz band, to minimize the feeder loss, it is likely that the input stages will be located at or near the focus of the antenna. Thus a dual reflector or offset antenna could be preferred because of high aperture efficiency (65 to 70%) and low feeder losses. On the other hand, with developments in microwave electronics, similar efficiencies are now possible with a normal focal feed. Successful designs in respect of cost and reliability were used in Canadian experiments at 12 GHz with linear polarization (Hermes and Anik-B experiments), a field-effect transistor (FET) amplifier and frequency changer unit are mounted at the focal point with a high-efficiency feed. Units with 1.2 m and 1.8 m diameter reflectors gave worst-case values of G/T of 11 dB(K^{-1}) and 15 dB(K^{-1}) respectively, including losses and an ageing allowance of 1 dB [CCIR, 1978-82a]. With the same technology the corresponding G/T for a 0.9 m reflector would be 9 dB(K^{-1}). These values are significantly greater than the 6 dB(K^{-1}) value used for planning at the WARC-BS-77. This Conference adopted the use of circular polarization for broadcasting satellites at 12 GHz. A short microwave feeder may be desirable to establish the polarization and/or give useful first-converter image attenuation; this would contribute a small additional coupling loss.

4. Input stages

These stages are an important part of the receiver. They should consist of a frequency down-converter which may or may not be preceded by low noise radio-frequency amplifier stages and a local oscillator.

If low noise pre-amplifiers are required, the field effect transistor (FET) is now widely used. For higher frequency bands such as 23 GHz, the low noise high electron mobility transistor (HEMT) has been developed, and because the cost has been greatly reduced, they are being introduced.

Hybrid MIC (microwave integrated circuit) amplifiers are generally used for low noise amplifiers to achieve lower noise figures and stable performance. In addition to this technique, monolithic GaAs FET amplifiers have been developed which will reduce the cost in the case of mass production.

Various data have been reported at present concerning noise performance for low noise elements, amplifiers and receivers for satellite broadcasting as shown in Annex V. As a summary, Table I shows the noise figure of receivers for frequency bands assigned to the BSS.

TABLE I

Summary of typical noise figures reported for present-day receivers (1989)

Frequency band (GHz)	0.7	2.6	12	23
Typical noise figure (dB)	1.5	1.5	1.8	5.0

It is noted that the configuration used to obtain the value of the noise figure should be clearly identified because the noise figure may be expressed for various configurations, e.g.: single element, amplifier or receiver. It is also noted that for consumer equipment used in the home, after ageing, characteristics such as the noise figure may be different from those available in laboratories.

A measurement of the distribution of the characteristics of direct converter 12 GHz receivers, which were selected among about 100 receivers developed for the BSE experiment, was carried out in Japan in 1980. As for distribution of the noise figure, results show that the initial value was 4.1 dB on average with a standard deviation of 0.25 dB. The degradation during two years was 0.15 dB [CCIR, 1978-82b].

For the first local oscillator, a solid state direct local oscillator source, such as a Gunn device, or a field-effect transistor (FET), may be used. To stabilize oscillator frequency, a phase locked oscillator (PLO) referenced by a crystal controlled oscillator or dielectric resonator oscillator (DRO) with high Q dielectric resonator is commonly used. However, even if some form of automatic frequency control of this or any subsequent local oscillator can be assumed, some care will still be necessary to minimize frequency drift with temperature. The design of the a.f.c. loop will depend on whether d.c. or a.c. coupling is used in the frequency-modulation transmitter modulator.

There is a prospect of reducing the number of components in the outdoor unit and hence the cost of the receiver, by applying such technologies as use of active mixers, and/or self-oscillating mixers which eliminates a separate oscillator. Introduction of planar geometries to the integrated type of antenna and low noise input stages using microstrip lines with co-planar and slot structures would facilitate the manufacturing process [CCIR, 1986-90a].

5. **Intermediate-frequency stages** [CCIR, 1974-78b, d, f and g]

For reception at 12 GHz the design will probably entail two frequency changes to ease problems of selectivity, image rejection and local oscillator radiation, but installations with only one frequency change cannot be ruled out. For the 700 MHz and 2600 MHz bands either arrangement may be attractive. When there is more than one frequency change, the first down-converter, equipped with a fixed frequency oscillator, should be placed close to, or on, the antenna. For 12 GHz reception, the choice of the value of the first intermediate frequency presents some difficulties, since these frequencies must be chosen so as to avoid interference by terrestrial broadcasting transmitters or by other services using radio transmissions of significant power.

Apart from this constraint the intermediate frequency should not be too high because, if a suitably low noise figure is to be maintained in the intermediate frequency amplifier, its cost increases significantly with frequency; likewise the down-lead coaxial cable tends to cost more for higher frequencies.

On the other hand, if the intermediate frequency is too low, it will be difficult to eliminate the image frequency. As, in the WARC-BS Plan for Regions 1 and 3, the frequency channels for most service areas form a group of four or five, lying within a bandwidth of up to 400 MHz, the tuning range of the receiver and consequently the range of the first intermediate frequency must cover at least 400 MHz and in some cases 800 MHz. Under those conditions, the first intermediate frequency may be chosen within the band 900 to 1700 MHz. However, as summarized in § 11.3, it may be helpful in some countries to use a higher intermediate frequency (e.g. 1500-2300 MHz) to avoid interference from radionavigation radars.

With a local-oscillator frequency lower than the signal frequency, the first image frequency might lie, in Region 1, within the band 9.1 to 10.3 GHz; an iris filter incorporated in the waveguide of the antenna connection would make it possible to obtain an attenuation of 80 dB of that image frequency, which may be necessary in some areas to give protection against maritime radar and other high-power navigational systems (see § 11.2).

Another factor in determining the first intermediate frequency is the selection of the first local oscillator frequency. In Japan, a first local oscillator frequency of 10.678 GHz is considered appropriate for the following reasons:

- emission of radio waves in the band 10.68 GHz to 10.7 GHz is prohibited, as a general rule (Article 8, Nos. 833 and 834 of the Radio Regulations, 1988);
- the maximum leakage power of the first local oscillator is assumed to be −40 dBW as the worst case, when a conventional direct converter is used;
- in Japan, radio-relay systems operating above 10.7 GHz and outside broadcasting links operating in the band 10.55 GHz to 10.675 GHz should be protected from possible interference by the leakage power of the first local oscillator.

In France, the frequency 10.750 GHz is normally used as first local oscillator; this corresponds to a first IF of between 950 and 1 750 MHz.

In the event that a radionavigation radar should cause interference to reception of a satellite channel, the frequency of the first local oscillator would be displaced by a multiple of 19.18 MHz.

A further discussion of unwanted radiation from receiving equipment is given in § 12.

Another item to be considered is the selection of the second intermediate frequency. The frequency must be chosen so as to avoid interference by terrestrial broadcasting and other transmitters. In this regard, use of frequencies near 130, 400 MHz and other possibilities are studied. The home receiver designed mainly for individual reception may possibly be applied to group reception; in this case a common front end is connected to more than one indoor unit. When the selected value of the second intermediate frequency is smaller than the value of the total frequency bandwidth at 12 GHz allocated for satellite broadcasting in a service area, local oscillator frequencies coincide with part of the first intermediate frequency band. Depending on the level of the received signal and leakage power, attention has to be given to mutual interference between indoor units caused by the local oscillator leakage. To make this interference as low as possible by arranging the second local oscillator frequencies between any two adjacent channels allocated to that area, the following relationship is desirable for the second intermediate frequency:

$f = 38.36 (n + ½)$ MHz (in Regions 1 and 3)

$f = 29.16 (n + ½)$ MHz (in Region 2)

where n is an integer.

This relationship is valid when the selected frequency f is smaller than the value of the total frequency bandwidth to that area. However, if $2f$ is smaller than the total bandwidth there is the possibility of image frequency interference, and a small adjustment of the value of f may be beneficial.

The second intermediate frequency, having a bandwidth of 27 MHz, might be chosen in the vicinity of 70 to 400 MHz, which would again make it possible to avoid the broadcasting bands. For a receiver used in Regions 1 or 3, this could be achieved through use of a 27 MHz four-pole filter. The attenuation at the second image frequency should be at least 30 dB [CCIR, 1978-82c].

Recent designs of home terminal receivers have shown that it may be practical to use surface acoustic wave (SAW) filters for the second IF. These filters are practical in the frequency range between 35 and 600 MHz and have very desirable properties of linear phase and sharp filter roll-off. Examples of the achievable amplitude versus frequency response of SAW filters are shown in Figs. 2a, b and c.

On the other hand most of the 4 GHz satellite television receivers in the fixed-satellite service in use in the United States use a second intermediate frequency of 70 MHz. A considerable amount of operating experience has been accumulated, and in addition a number of circuit designs have been developed and field tested. This technology should be directly applicable to 12 GHz receivers and receivers operating in other bands [CCIR, 1978-82d].

An alternative approach is the use of a phase-locked loop to obtain the video signal. If this can operate directly at the first intermediate frequency it avoids the need for a second intermediate frequency [CCIR, 1978-82c]. It should be noted, however, that the loop bandwidth of some phase-locked-loop designs is comparatively wide and may result in the demodulation of adjacent channels. Therefore, use of some phase-locked-loop designs as described may be limited to areas where the received BSS channels are separated by a sufficient spacing and where signals from transmitters operating in other services, the fixed service for example, do not lie too near the desired BSS channels. A large percentage of 4 GHz satellite television receivers in use in the United States use a phase-locked-loop to demodulate the TV carrier at the second IF [CCIR, 1978-82d].

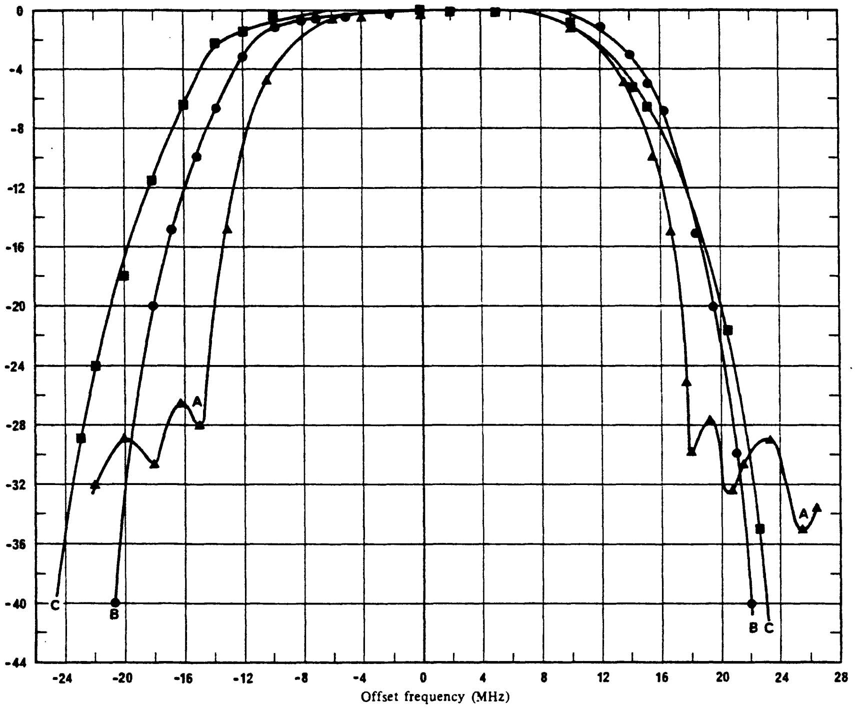
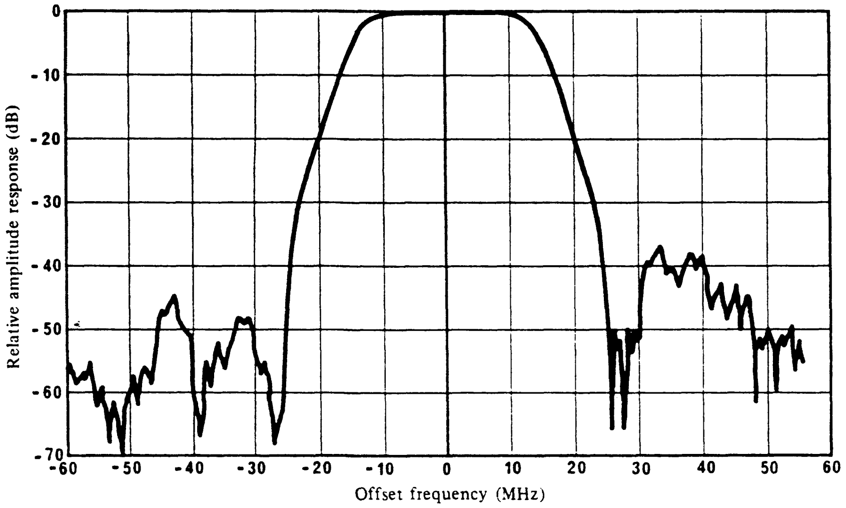


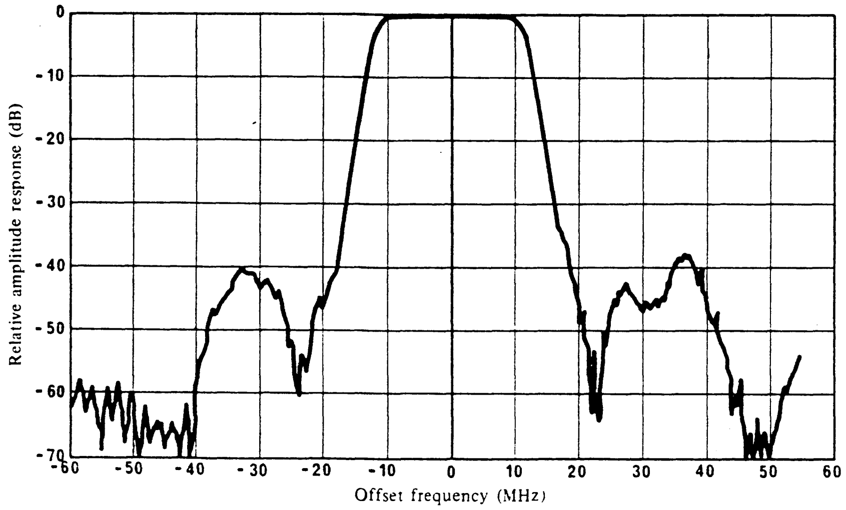
FIGURE 2a – *Amplitude versus frequency response of SAW filters (second IF)*

Curves	Centre frequency (MHz)	Equivalent slope
A	260	6-pole Chebychev
B	130	6-pole Chebychev
C	130	5-pole Chebychev



Centre frequency = 134.3 MHz
Bandwidth = 27 MHz

FIGURE 2b – *Amplitude versus frequency response of SAW filter*



Centre frequency = 140 MHz
Bandwidth = 23 MHz

FIGURE 2c – *Amplitude versus frequency response of SAW filter*

6. Demodulation or adaptor stages

For television, use can be made of a frequency demodulator which will deliver the video signal (and possibly frequency- or digitally-modulated sound signals on sub-carriers, if sub-carriers are used for sound component transmission). In the long term it is expected that these stages, together with the programme selection stages referred to in § 5, would be incorporated into television receivers designed for reception of both frequency-modulation satellite and amplitude-modulation terrestrial emissions. In the interim period, the video signal can directly feed a receiver at video frequency, or amplitude modulate a carrier, to produce a conventional signal which then feeds an ordinary type of domestic receiver. In the latter case, generation of a standard vestigial-sideband signal is ideally desirable, but in practice is not essential. Devices for direct FM-AM conversion without intermediate demodulation are under study but the possible use of signal pre-emphasis and/or energy dispersal may complicate their design.

Integrated circuit and discrete component threshold extension demodulators comparable in complexity to conventional FM demodulators but using phase lock loops, FM feedback or tracking filters may be cost effective for some BSS applications. Dynamic thresholds occurring at carrier-to-noise ratios of approximately 8 dB are presently achievable with average programme level modulated colour signals.

In order to reduce the possibility of interference to other services, a measure of energy dispersal is often required for satellite broadcast signals. For individual reception in the 12 GHz band, the WARC-BS-77 adopted the use of energy dispersal to ensure that the energy in any 4 kHz band is at least 22 dB below the total assigned power. For television signals, such dispersal may be achieved by adding to the video signal, before application to the feeder link, a periodic sawtooth or symmetrical triangular waveform with a repetition frequency equal to a half, or a quarter, of the field frequency. A peak-to-peak carrier deviation of 600 kHz arising from the dispersal waveform is sufficient to meet the requirement. The dispersal waveform must be removed from the video signal obtained from the demodulator if it is not to cause visible effects on the displayed picture. Experience suggests that a simple low-cost d.c. restorer will be adequate for this purpose when using a dispersal waveform of the magnitude indicated.

In Region 2 an energy dispersal technique appears to be particularly suitable for community reception type receivers operating in the 12 GHz band. However, further study is required to determine the impact of its use on the design complexity and cost of the demodulator or adaptor stages.

As for the distribution of video signal impairments, measurements on receivers used for the BSE experiment showed that the differential gain and phase had average values of 2.1% and 1.8° with a standard deviation of 0.9% and 0.8° respectively. The measurements also indicated that degradations in differential gain and phase were 1% and 0.5° during two years [CCIR, 1978-82b].

The demodulation stages of home receivers intended for reception of a digitally-modulated sub-carrier system may consist of an FM demodulator, a 4-PSK demodulator and a PCM signal processor.

The sound sub-carrier signals are fed to the PSK demodulator through the bandpass filter. The PSK demodulator, performing phase lock detection of the 4-PSK signal, regenerates PCM signals and the clock frequency synchronized to them. The PCM signal processor performs de-interleave, error correction and other PCM signal processing, if necessary, and then converts digital signal into analogue signal through the D/A converter. And if necessary, all PCM bit-stream signals with error correction may be provided for the use of independent data and sound broadcasting, in order to meet the needs of the various services of satellite broadcasting.

There is a trend to provide an increasing number of consumer television receivers equipped with RGB interfaces. Demodulators and decoders generating RGB signals are now made available to provide high picture quality.

7. Community reception and distribution techniques

In satellite broadcasting, the concept of signal reception, not only for individual reception but also for community receiving installations, has been established. To this end it is necessary to use suitable reception and distribution techniques satisfying, as much as possible, the requirements of maximum commonality between individual and community receivers.

For example, in Japan about half of the 1.7 million households that were receiving satellite-broadcasting programmes in mid-1989 were receiving these programmes via cable networks using either AM or FM distribution techniques. Moreover, small community reception installations using FM distribution techniques are increasing in number.

7.1 Distribution techniques

According to studies conducted in Italy and Japan, two possible FM distribution techniques for community reception can be envisaged [Mussino, 1984; REEA, 1987; CCIR, 1982-86c]:

(a) Distribution in the first IF band (e.g.: 0.95-1.75 GHz) of up to 20 FM channels spaced 38.36 MHz (or more), without changing the RF modulation parameters of BSS signals.

This technique is applicable to the case where constraints from spectrum occupation or use of high frequencies do not exist.

(b) Distribution in the VHF or UHF TV broadcasting bands including the extended UHF band (e.g: 230-470 MHz) of a few selected FM channels, spaced 38.36 MHz (or more), without changing the RF modulation parameters of BSS signals.

This technique can be used when the availability of a limited number of channels is acceptable to the users.

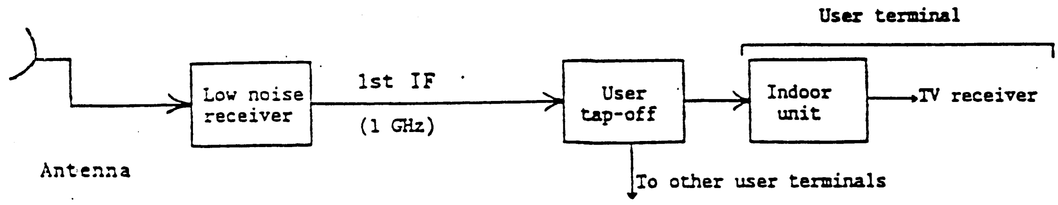
Appropriate safeguards may be necessary against accidental leakage in order to prevent interference to other services, in particular in the allocation for emergency position-indicating radiobeacons (EPIRBs) at 243 MHz and 406-406.1 MHz.

Examples of practical implementation of distribution techniques (a) and (b) are shown in Figs. 3a) and b) and 4a) and b), respectively.

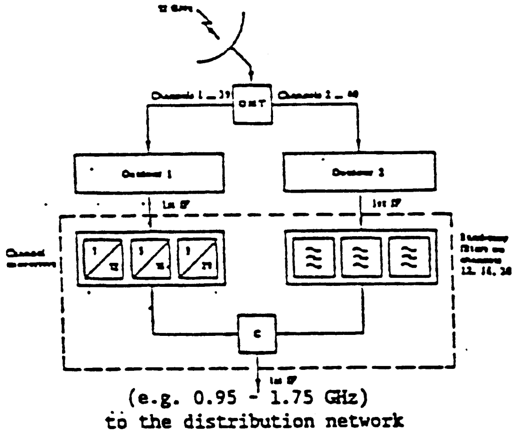
For the techniques illustrated in Fig. 3(b), channel converters and band-stop filters are used to select an combine the 20 wanted channels among those (up to 40) received from each satellite orbital position. In this example, channels 1, 5 and 9 are converted and distributed in place of channels 12, 16 and 20, which are suppressed by the band-stop filters. For the techniques illustrated in Fig. 4(b), channels 1, 5 and 9 and channels 24, 28 and 32 are converted into the band 230-470 MHz. In the indoor unit, the 230-470 MHz band is selected and converted into a suitable part of the first IF band.

In the case of community-receiving installations, where the above distribution techniques (a) and (b) cannot be used, the use of AM/VSB remodulation may be necessary in order to minimize the channel bandwidth.

Reference should be made to Report 482 and the relevant texts of Volume XI-1.



(a) Method of providing all channels transmitted on the same polarization

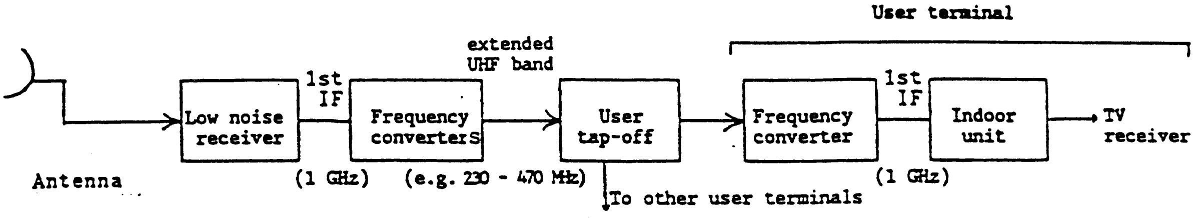


OMT: ortho-mode transducer
C: combiner

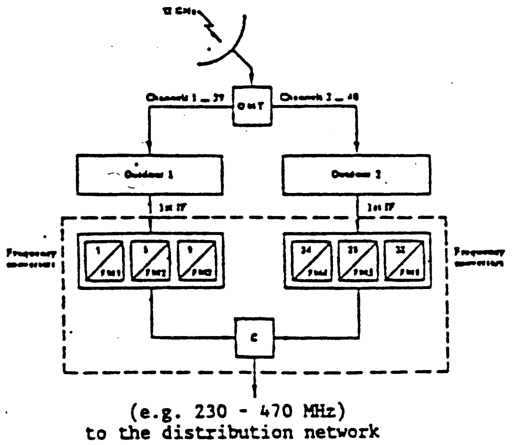
(b) **Method of providing selected channels from both polarizations**

FIGURE 3

Examples of the distribution technique in the first IF band



(a) Method of providing selected channels transmitted on the same polarization



OMT: ortho-mode transducer
C: combiner

(b) **Method of providing selected channels from both polarizations**

FIGURE 4

Examples of the distribution technique in the extended UHF band

7.2 Impairments affecting the distributed signals

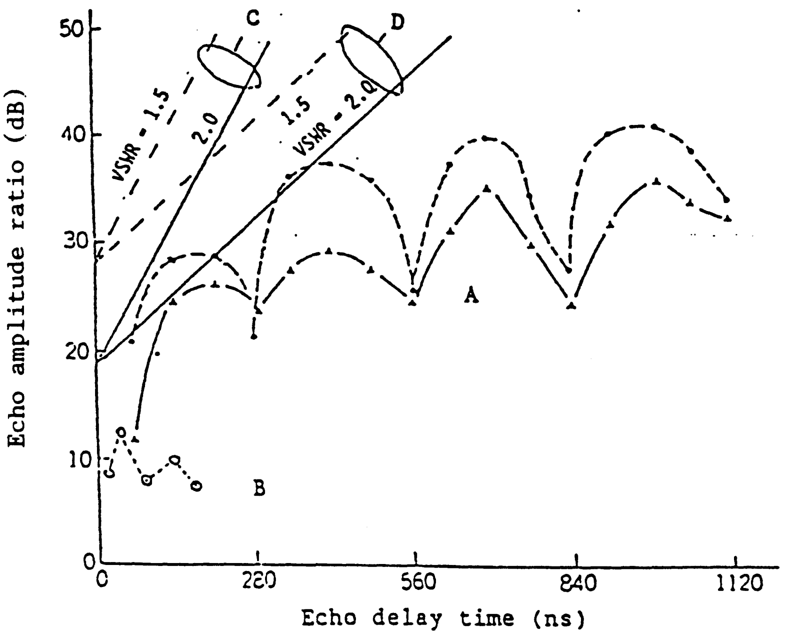
In small collective antenna systems, the BSS signals, distributed according to FM techniques (a) and (b)(see § 7.1), can be impaired with respect to direct reception, because of imperfect matching between the various parts of the installation, especially the distribution network. Other impairments can be introduced because of imperfect alignment of the head-end unit devices (e.g. channel and frequency converters, band-stop filters, amplifiers, etc.).

The corresponding alterations of the frequency response (amplitude and group delay) at the user outlets affect the spectral distribution of both signal and noise. The C/N ratio, at the receiving filter output, is then changed with respect to direct reception, depending on the carrier frequency of the BSS signals distributed in the network. Consequently, the demodulated signal is affected by waveform distortions, impairments of the S/N ratio and increase of impulse noise at low C/N ratios.

Theoretical studies, as well as laboratory and field tests, were carried out on the cable distribution systems in Japan [CCIR, 1986-90b]. Based on these studies, it is shown that both AM and FM distribution techniques are practical. As for FM distribution techniques, it is considered that some care regarding the mismatching of impedances of components is necessary to avoid echoes. Figure 5 shows an example of the relationship between the echo amplitude ratio and delay time in the cable distribution system which gives just perceptible flicker impairment. This also shows that mismatches resulting in a VSWR of 1.5 would be acceptable in such systems.

Results of the field tests show that there are no major problems of applying FM distribution techniques to the cable distribution systems if selected distribution units with appropriate characteristics are used.

For further information, see Annex VI.



Legend

Curves A - Just perceptible flicker
-•-•-•-- for the colour bar signal
—Δ—Δ— for the test pattern of the kitchen scene
Curve B - Measured BER for 10^{-8}
Lines C - Cable loss 0.4 dB/m
Lines D - Cable loss 0.2 dB/m

FIGURE 5

Echo amplitude ratio vs. echo delay time which gives just perceptible flicker impairment

Laboratory tests have been carried-out in France [CCIR, 1986-90c] on D2, D, C-MAC/packet signals, in order to evaluate the impairments on both sound/data and vision components introduced by a single echo added to the direct signal at the second IF of 230 MHz.

With regard to the sound/data component, Table II gives the values of C/N measured at a bit error ratio of 1 x 10^{-3}.

The C/N impairments with respect to direct reception, measured for an echo level of -15 dB were 1 dB for D2, 1.5 dB and 1.7 dB for C (with FM and 2-4 PSK demodulation, respectively) and 2 dB for D signals. The D signals showed higher sensitivity than D2 and C signals to frequency offset.

With regard to the MAC vision component, the main effect of a short echo, less than 100 nsec delayed, was the impairment of the S/N ratio of the demodulated signal.

For a C/N ratio of 16 dB in 27 MHz, 1 dB and 2 dB impairments of the luminance S/N ratio (weighted) were measured for echo levels of -20 dB and -15 dB, respectively. For a C/N ratio of 12 dB, an echo level of -15 dB corresponded to the visibility threshold of impulsive noise. Details of these laboratory tests are given in Annex VII.

Experimental investigations have been carried out in Italy [Cominetti and Stroppiana, 1986; CCIR, 1986-90d] to evaluate the impairments introduced on C-MAC/packet signals by the distribution network of collective antenna systems implemented according to technique (b) of section 7.1, in the extended UHF band (230 - 470 MHz), assuming ideal performance of the head-end unit devices.

With regard to the sound/data component, Table III gives the measured C/N ratio in 27 MHz corresponding to a bit error ratio of 1 x 10^{-3}, at the receivers where the worst reception quality was found, for the cases of differential demodulation and conventional frequency demodulation of the 2-4 PSK C-type signal. Maximum C/N impairments of 1.8 dB and 2.3 dB were measured for the two types of demodulation, respectively.

TABLE II

C/N ratio (dB) measured in 27 MHz corresponding to a bit error ratio of 1 x 10^{-3}

Type of modulation	Type of demodulation	Bandwidth of receiving filter	Frequency offset in receiving filter	C/N (dB) for echo level		
				None	- 20dB	- 15dB
D2	limiter-discriminator	27 MHz	$\Delta f = 0$	8	8	9
	limiter-discriminator	27 MHz	$\Delta f = 2.5$ MHz	8.4	9.0	9.5
C	limiter-discriminator	27 MHz	$\Delta f = 0$	9.5	10.3	11
	limiter-discriminator	27 MHz	$\Delta f = 2.5$ MHz	10.3	11.5	11.8
	differential	21 MHz	$\Delta f = 0$	7.3	8.5	9.0
D	limiter-discriminator	27 MHz	$\Delta f = 0$	10.5	11.2	12.5
	limiter-discriminator	27 MHz	$\Delta f = 2.5$ MHz	10.9	12.2	14.2

TABLE III

C/N ratio (dB) measured in 27 MHz corresponding to a bit error ratio of 1×10^{-3} for 2-4 PSK C-MAC/packet sound/data signals with differential and frequency demodulation

Condition		C/N (dB) for type of demodulation:	
		Differential	Limiter/discriminator
Modulator-demodulator, direct connection		7.6	10.1
Distribution network	Best condition	7.6	9.3
	Worst condition	9.4	12.4

With regard to the MAC vision component, no significant waveform distortions were found. The main impairment was due to the reduction of the C/N ratio, reaching at most 2 dB.

Details of the laboratory implemented installation are given in Annex VII.

According to the results obtained in France and Italy, referring to FM distribution of BSS MAC/packet family signals, a C/N ratio of about 2 dB higher than that achieved by an ideally matched receiving system should be necessary in order to overcome the impairments due to the distribution network.

Further studies are necessary to evaluate the additional impairments introduced by the other components of the receiving installations.

8. Reception of sound broadcasts

For individual reception at 12 GHz of sound-only broadcasts or of supplementary sound channels associated with television broadcasts, it would seem desirable to be able at least to use the same input stages as for the reception of television signals. To avoid the need for a highly stable local oscillator in the input stages and to simplify the demodulation stages, it is possible that a number of sound programmes may be multiplexed within a video signal bandwidth, and used to frequency modulate a 12 GHz transmission, having a power and bandwidth comparable with that used for a satellite television transmission. This multiplexing could be achieved with analogue FM frequency division multiplex or with digitally modulated signals in frequency or time division multiplex (see Report 215 for system examples). Although less efficient than separate FM carriers in terms of use of bandspace and power, such arrangements would have significant advantages for tuning. Studies of such possibilities are in progress.

9. Effect of channel grouping

The interdependence of receiver design, channel grouping and sharing criteria may have a considerable influence on the development and the implementation of a plan for the broadcasting-satellite service (Recommendation No. 712 of the WARC-79).

Measurements were carried out in Japan using down-converter type receivers with a double conversion structure, compatible with the technical characteristics and with the plan which was adopted at the WARC-BS-77. The results indicate that the channel grouping of the plan for the broadcasting-satellite service in the 12 GHz band is unlikely to cause deterioration in the reception of television; measured levels of intermodulation were fairly low and the rejection characteristics of adjacent channels were satisfactory.

Further study of this matter is desirable.

10. Cost consideration

The relationship between cost and the overall performance of receiving equipment, measured by the figure of merit, G/T, involves other factors, such as the quality of workmanship, the extent of the tests carried out after manufacture, the reliability objective, installation costs, etc. Cost studies both for items of equipment and for complete installations have shown substantial differences between the estimates obtained from various sources; even after these estimates have been adjusted for a similar basis and for similar performance factors.

Installation tests, carried out in Sweden [CCIR, 1978-82e] show that the installation costs for individual TVRO terminals for 12 GHz, installed by installation engineers, are about 1 to 1.5 times the estimated factory cost for 12 GHz terminals for quantities of 10^5 units, Although these cost estimations are primarily valid for Sweden they indicate that the installation cost should not be ignored when determining the overall costs of the broadcasting-satellite system [CCIR, 1978-82e].

11. Susceptibility to certain types of interference

A receiver having the characteristics suggested in § 5 would be expected from theoretical considerations to be susceptible to the following forms of interference; experience and measurements in practical situations are required to assess the true extent of any interference problem.

11.1 *Harmonics of certain emissions falling into the broadcasting-satellite band*

This risk has its origin in harmonics radiated by ISM equipment and in particular domestic microwave ovens. A study [CCIR, 1978-82c] has shown that the risk remains slight, if the ISM equipment does not exceed the limit of parasitic radiation recommended by the CISPR, namely 57 dB(pW). That limit ought to be interpreted as applying to the total power in a bandwidth of 27 MHz. The population of domestic microwave ovens is now sufficient in many places to permit realistic measurements to be made in the field. In many urban areas, however, a microwave oven may be located near the receiving antenna in the broadcasting-satellite service. Limitation on the location of the oven for prevention of possible interference into receivers is given in Annex VIII. The computed distances are based on, among other things, an assumed 5th harmonic effective radiated power (e.r.p.) of 57 dB(pW) and may not represent the worst case value [CCIR, 1978-82b].

11.2 *Emissions in the first image band (9.1 to 10.3 GHz in Region 1)*

This risk, which arises if the first local oscillator frequency is below the signal frequency, has its origin in certain very-high-power radar stations. A study [CCIR, 1978-82c] has shown that the range of the interference may reach 27 km. Thus the problem is a serious one and could be resolved at the level of the receiver by choosing the frequency for the first local oscillator above that of the signal, to avoid the disadvantage given in § 5 of requiring, in some areas, an image rejection of 80 dB [CCIR, 1978-82f].

11.3 *Emissions in the band of the first intermediate frequency*

If the intermediate frequency band lies in the range 900 to 1700 MHz, there is a serious risk of extraneous interference, mainly from radionavigation transmitters which may produce an e.i.r.p. of several kilowatts.

Measurements were carried out in France that confirmed the presence of a field strength of the order of 10 V/m a few metres above the ground up to at least 10 km away. The field strength was in fact found to depend on the height of the point of measurement and, considering that a number of users of broadcasting-satellite services will be connected by cables to distribution networks running inside buildings or tower blocks, the actual interference zone may be considerably larger and may extend as far away as 20 km [CCIR, 1982-86d]. Another study [CCIR, 1978-82g] has shown that a separation distance of 11 km may be required, assuming the screening of the IF interconnection and circuits to be typical of present practice for UHF broadcast receivers.

Measurements made in Australia [CCIR, 1982-86e] showed that certain receivers displayed interference with a radar field strength of 0.35 V/m. The interference disappeared when the wanted signal level was increased by 6 dB above FM threshold. During the same test another receiver showed interference in field strengths above 1.6 V/m. One receiver that could only be tuned such that the radar frequency and the wanted IF signal were separated by 10 MHz was able to operate in field strengths up to 39 V/m [DOC, 1985].

In order to avoid picture impairments due to such interference problems, there are at least two solutions:

- use of receiving equipment with protection against this risk by using a suitable well-screened construction and suitably designed components: in particular the SHF converter (which should have a high gain but low intermodulation levels) and the down-lead conveying the signals at intermediate frequency. This may call for the development of specific components and for the IEC to establish appropriate methods of measuring interference immunity [CCIR, 1978-82h]. However for the mass market, it may be too expensive to equip all receiving stations with a perfectly screened and decoupled selector/demodulator, and the manufacture of specially screened versions is not necessarily compatible with the consumer market;
- choice of the band 1500-2300 MHz as an intermediate frequency. This raises problems of technology that may be solved in the future with foreseen improvements in electronic components.

11.4 *Intermodulation*

Attention has been drawn to a possible problem arising from the large number of third-order intermodulation products that could be present in the wanted signal channel when using a wide-band first converter (e.g. over a hundred products for a case when twenty equally-spaced signals might be present in an 800 MHz band) [CCIR, 1978-82i].

Linearity requirements in the converter and IF amplifiers must therefore take into account the number of television signals of significant amplitude that may be present within the first IF bandwidth.

12. **Unwanted radiation from receiving equipment** [CCIR, 1982-86f]

A potential source of unwanted radiation from BSS receiver terminals is the first local oscillator (LO). Front-end receiver designs using a direct mixer approach could have local oscillator levels as high as -50 dBW at the antenna flange. Receivers with pre-amplifiers as the first stage will typically have levels of -65 to -70 dBW. Further reduction of these levels would be required to prevent possible interference into FS and FSS bands if the frequency selected for the first LO fell in bands allocated to these services. The following are two possible methods for reducing the impact of local oscillator radiation:

- select a frequency for the local oscillator for all BSS home terminals that will not cause unacceptable interference to other services. An example of such a frequency would be 11.2 GHz that is at the centre of the guard band between the low band and high band of the 10.7 to 11.7 GHz fixed service allocation;
- use a single conversion receiver for BSS home terminals thus keeping the local oscillator frequency within the BSS band.

Although this latter approach is commonly used in the FSS at 4 GHz, it is really not suitable for the BSS since it would require a tunable local oscillator in the outdoor unit. In addition, this approach would require careful satellite frequency channelization to ensure that the in-band image frequency falls on cross-polarized channels.

Careful selection of the local oscillator frequency at some point either above or below the receive band could minimize image rejection requirements depending upon which signals fall into the image band. Other technical factors need to be considered in selecting the best approach to minimizing unwanted radiation, for example:

- other spurious responses created in the receiver by the local oscillator frequency selected; and
- benefits from waveguide cut-off.

Another potential source of unwanted radiation is the clock frequency oscillators in the decoders used in the receiving equipment. The highest clock frequency in MAC/packet decoders used in 625-line/50 Hz domestic television equipment is 3/2 times that of the digital television coding standard, i.e. 20.25 MHz. Certain harmonics of this clock frequency coincide with the centres of the emergency frequency channels at 121.5 MHz and 243 MHz in the aeronautical mobile and mobile satellite frequency bands.

The electromagnetic radiation limits for mass produced equipment are the subject of existing specifications, CISPR Recommendation 13-1975 (Applying to broadcast receivers) and CISPR 22-1985 [CISPR, 1985] (Applying to information technology equipment). These recommendations are intended to ensure electromagnetic compatibility between such equipment and radiocommunication services.

CISPR Recommendation 13-2-1989 [CISPR, 1989] is a new issue of Recommendation 13 which applies to broadcast recievers and associated digital equipment and specifies radiation limits on aeronautical maritime distress frequencies (121.5 MHz and 243 MHz) indentical to CISPR Recommendation 22.

This is consistent with the conclusions of a study on potential interference from MAC/packet equipment into, inter alia, the SARSAT system on aeronautical maritime distress frequencies (121.5 and 243 MHz) made by the EBU [CCIR 1986-90e] which have been incorporated together with input from Study Group 8 into Report 1101. However, a study by the United States relating to interference to SARSAT operations on these frequencies concluded that a decrease in the radiation limits defined by CISPR might be required to protect the SARSAT system [CCIR, 1986-90f].

This matter should be the subject of further consideration in Study Groups 1 and 8.

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[1978-82]: a. 10-11S/59 (Canada); b. 10-11S/113 (Japan); c. 10-11S/8 (EBU); d. 10-11S/141 (USA); e. 10-11S/125 (Sweden); f. 10-11S/45 (France); g. 10-11S/62 (Japan); h. 10-11S/47 (France); i. 10-11S/46 (France).

[1982-86]: a. 10-11S/137 (Japan); b. 10-11S/171 (France); c. 10-11S/175 (Italy); d. 10-11S/13 (France); e. 10-11S/192 (Australia); f. 10-11S/17 (USA).

[1986-90]: a. 10-11S/145 (Italy); b. 10-11S/104 (Japan); c. 10-11S/56 (France); d. 10-11S/25 (Japan); e. 10-11S/4 (EBU); f. 10-11S/167 (USA).

ANNEX I

EXAMPLE OF CALCULATION OF THE FIGURE OF MERIT OF RECEIVING EQUIPMENT FOR INDIVIDUAL RECEPTION IN THE 12 GHz BAND

For the present example, the figure of merit, G/T, is defined by the following formula, which allows for pointing error, polarization effects, and ageing:

$$G/T = \frac{\alpha \beta G_r}{\alpha \, T_a + (1-\alpha) \, T_0 + (n-1) \, T_0}$$

where:

α : the total coupling losses, expressed as a power ratio,

β : the total losses due to the pointing error, polarization effects and ageing, expressed as a power ratio,

G_r : the effective gain of the receiving antenna, expressed as a power ratio and taking account of the method of feeding and the efficiency,

T_a : the effective temperature of the antenna (either clear sky or for a given percentage of the time),

T_0 : the reference temperature = 290 K,

n : the overall noise factor of the receiver, expressed as a power ratio.

Relatively inexpensive receivers can be produced having a maximum noise figure of 4 dB (438 K). An example of the calculation of "nominal" and "usable G/T", using this noise figure and assuming an antenna diameter of 90 cm and an efficiency of 55%, is given in Table IV [CCIR, 1982-86a]. The following expression may be used to calculate the pointing loss P in dB:

$$P = -12 \left[(\theta_1^2 + \theta_2^2 + \theta_3^2)/\theta_0^2\right]$$

where:

θ_1 : the initial pointing accuracy of the fixed-mount receiving equipment in the direction of the satellite (degrees),

θ_2 : the pointing stability of the receiving equipment under the influence of the climatic environment (degrees),

θ_3 : the orbital drift of the satellite (degrees),

θ_0 : the half-power beamwidth of the receiving antenna (degrees).

It is also possible to obtain the same result with other combinations of parameters. Figure 6 shows an example of how the antenna gain, the antenna diameter and noise figure may have a range of values. It is interesting to note that as the value of noise figure is reduced, the influence of the increase in antenna noise temperature on the antenna gain and diameter required for a given "nominal" and "usable G/T" is magnified.

The effective antenna noise temperature is determined by its size and elevation angle, external noise sources, and atmospheric propagation effects. The smaller the antenna, the greater the relative gain of the pattern pointing to the Earth (side-lobes also intersect the ground at a higher antenna elevation angle). Consequently, the smaller the antenna, the higher the elevation angle at which its noise temperature approaches 290 K.

The effect of atmospheric attenuation of the signal is also to raise the effective antenna noise temperature, T_a, according to the relationship:

$T_a = T_m (1 - 1/L)$ (T_a is effective antenna noise temperature)

where:

T_m = 280 K, and

$L = 10^{0.1A}$ (A is the atmospheric attenuation in dB)

Thus, for high atmospheric attenuation, T_a approaches 280 K even for high angles of elevation.

TABLE IV – *Example of the calculation of the figure of merit (G/T)* *

		"Nominal G/T"		"Usable G/T"	
Gain of receiving antenna G_r (90 cm diameter, 55% efficiency)	(dB)		38.2		38.2
Coupling losses α	(dB)		$\underline{-0.5}$		$\underline{-0.5}$
Net gain αG_r	(dB)		37.7		37.7
Antenna temperature T_a (clear sky)	(K)	80		80	
Temperature referred to the input αT_a	(K)	71		71	
Coupling noise $(\alpha - 1)\ T_0$	(K)	35		35	
Increase in antenna temperature for 99% of the worst month	(K)	–		70	
Receiver noise temperature	(K)	438		438	
Total effective noise temperature	(K)	544		614	
or	(dBK)	⟶	27.4	⟶	27.9
Initial pointing accuracy of the antenna θ_1	(degrees)	–		0.4	
Pointing stability of the antenna θ_2	(degrees)	–		0.4	
Orbital drift of the satellite θ_3	(degrees)	–		0.1	
Aperture of half-power beamwidth of the antenna θ_0	(degrees)	–		1.8	
Pointing loss $P = -12\left[(\theta_1^2 + \theta_2^2 + \theta_3^2)/\theta_0^2\right]$	β (dB)		–	⟶	−1.0
Ageing and polarization losses	β (dB)		–		−1.0
G/T	(dB(K^{-1}))		10.3		7.8

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* Calculated at 11.7 GHz.

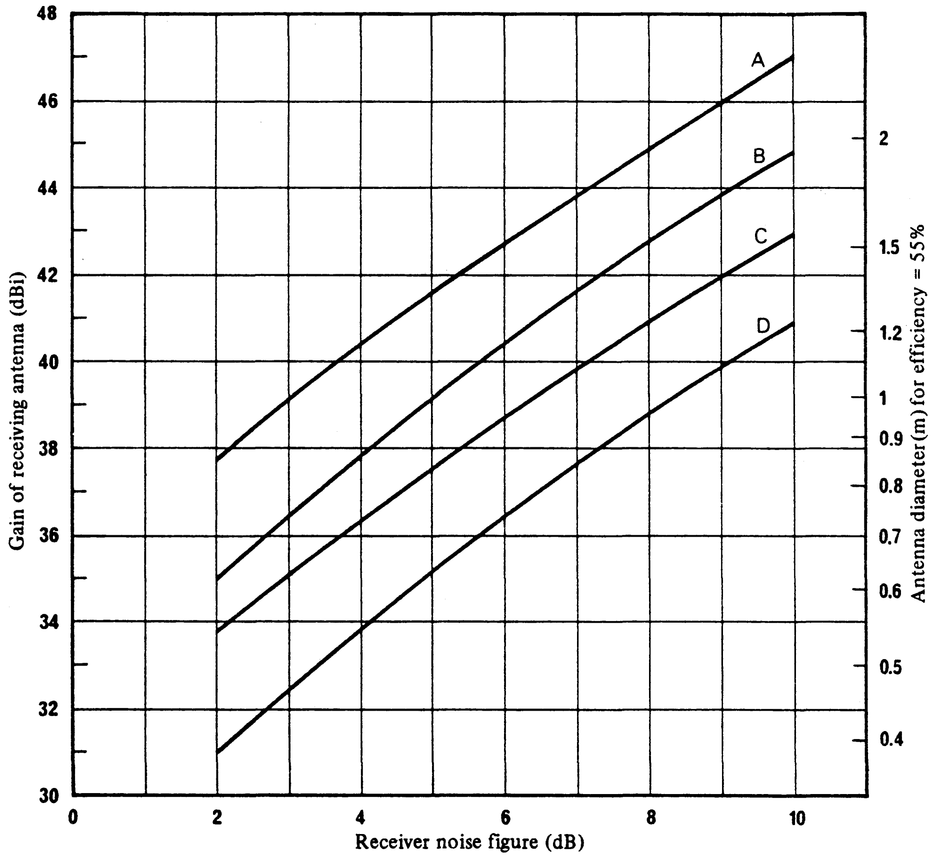

FIGURE 6 – *Relationship between noise figure, antenna diameter and antenna gain for "nominal" and "usable G/T" = 6 dB(K^{-1}) or 10 dB(K^{-1}) with losses and antenna temperature as in the example of* Table IV

A : "usable G/T" = 10 dB
B : "nominal G/T" = 10 dB
C : "usable G/T" = 6 dB
D : "nominal G/T" = 6 dB

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ANNEX II

CHARACTERISTICS OF HOME RECEIVING EQUIPMENT FOR SATELLITE BROADCASTING AT 12 GHz IN JAPAN

Television satellite broadcasting at 12 GHz has started in Japan and small-size high-quality home receiving equipment which consists of an antenna and receiver, is in practical use [CCIR, 1982-86a].

Table V shows the characteristics being established as a baseline for design and mass production. For the characteristics, the following are taken into consideration:

- minimization of interference with other services, as well as mutual interference between indoor units;
- standardization of electrical and mechanical interface parameters in order to ensure interchangeability of units;
- maintenance of high reception quality and ensuring flexibility with respect to the extension of broadcasting services in the future.

Several circuit technologies are used to construct mass-production type outdoor and indoor units. Offset feed type antennas are exclusively used for the smaller sizes.

In August 1989, more than 1.7 million of the households were receiving programmes via the BS-2 satellite either by direct or by community reception and this number is rapidly increasing.

Table V also gives the average performance of mass produced receiving equipment available in the marketplace in the beginning of 1989. This is based on the experiences of nine manufacturers in Japan.

REFERENCES

CCIR Documents

[1982-86]: **a.** 10-11S/137 (Japan).

TABLE V – *Summary of basic characteristics of home receiving equipment in Japan*

Item	Preferred characteristics (1)		Results of measurements (2)
1. *General:*			
– Receiving frequency (GHz)	11.7-12.1		–
– Figure of merit (dB(K^{-1}))	6 (3)		14.5 for 75 cm type
2. *Antenna:*	Effective diameter (cm)	Gain (dB)	
– Effective diameter and gain	45	32.0	–
	75	36.5	37.7 (Efficiency = 68%)(4)
	90	38.0	–
	100	39.0	–
	120	40.0	41.2 (Efficiency = 65%)
– *Directivity:*			
– half-power beamwidth	Fig. 2 of Report 810		2°20' (for 75 cm type)
– side-lobe relative gain			6°: –31 dB 12°: –40 dB 18°: –45 dB (for 75 cm type)
– polarization	Circular polarization (RHCP)		–
3. *Outdoor unit:*			
– Noise figure (dB)	< 4		1.8
– Image frequency suppression (outdoor unit) (dB)	> 31		40
– Overall gain (dB)	48 ± 4		48 ± 2
– 1st local oscillator:			
– frequency (GHz)	10.678		–
– stability (MHz)	± 1.5 (4)		± 1.0
– leakage power (dBm)	< –30 (5)		< –45
– 1st intermediate frequency (GHz)	1.036-1.332		–
4. *Indoor unit:*			
– Leakage power at 2nd local oscillator (dBm)	< –55		< –60
– IF bandwidth (MHz)	27		–
5. *Performance:*			
– Signal-to-noise ratio of the video signal (dB)	> 37 peak-to-peak/r.m.s. (unweighted)		38 peak-to-peak/r.m.s. (C/N = 14 dB)
– Bit error ratio of PCM signal	< 3 × 10^{-4} (before error correction, C/N = 9 dB)		1.5 x 10^{-4}

(1) All characteristics shown in this table are considered to be satisfied within the standard environmental conditions which are specified individually.

(2) The values indicated are the mean value of samples at 11.85 GHz.

(3) Different figures may be selected dependent on system performance such as satellite e.i.r.p. and received quality.

(4) With automatic frequency control (AFC).

(5) This value is applicable when harmful interference to other services due to local oscillator leakage can be eliminated by an appropriate frequency arrangement.

ANNEX III

EXAMPLES OF CHARACTERISTICS OF RECEIVING EQUIPMENT IN ITALY [CCIR, 1986-90a]

TABLE VI

Item	Characteristics
1. Receiving frequency range (GHz)	11.7-12.5
2. Antenna diameter (cm)	60-90
3. Image frequency attenuation (dB)	> 90
4. Stability of local oscillator (LO) frequency (MHz)	± 1.6 for an LO frequency of 10.750 GHz
5. Maximum radiated power at the LO frequency (dBm)	−42
6. Output frequency range (GHz)	0.95-1.75
7. Noise figure of the outdoor unit (dB)	≤ 2.0
8. Demodulation threshold of the indoor unit (dB)	≤ 10
9. **Clear sky C/N received from Olympus (dB)**	**18.5-22**

REFERENCES

CCIR Documents

[1986-90]: a. 10-11S/145 (Italy)

ANNEX IV

EXAMPLES OF CHARACTERISTICS OF RECEIVING EQUIPMENT FOR TDF-1 (FRANCE)

TABLE VII

Type of antenna	C/N measured in clear sky (dB)	Calculated G/T in clear sky (dB(K^{-1}))	Stated noise figure (dB)
30 cm Ø dish focal feed on the axis of revolution	18	6.8	1.3
33 cm Ø dish rear feed helical source	18.2	7	1.8
Flat antenna 72 x 72 cm	20.5	9.3	2.3
49 cm Ø dish offset feed	21	9.7	1.8
55 cm Ø dish offset feed	21.7	10.4	2.9

<u>Note</u> - The nominal frequency of the first local oscillator is 10.750 GHz, and the first intermediate frequency is selected between 950 and 1 750 MHz.

ANNEX V

NOISE FIGURE DATA

Various data have been reported convering the input stages of receivers for satellite broadcasting. Table VIII is a summary.

TABLE VIII

Reported noise characteristics for satellite broadcasting receivers

No	Reference	Freq.	Low noise element	Noise Figure	Remarks
1	CCIR, 1978-82a(USA)	700MHz		1.5dB	
2	CCIR, 1978-82a(USA)	2.5GHz		1.5dB	
3	CCIR, 1978-82b(F)	12GHz	FET	3.6dB	BW=400MHz
4	CCIR, 1978-82c(J)	"	Direct conv.	4.1±0.25dB	2 years degradation 0.15dB
5		"	FET, NF=1.8dB	2.5dB	carefully adjusted
6		"		3.5dB	expected
7	Konishi, 1979,80	"	Dir. conv./FET	4dB	BW=800MHz
8	"	"		3.4-3.6dB	BW=300-500MHz
9	CCIR, 1978-82a(USA)	"		4dB	soon obtainable
10	"	"		4.5dB	reduce cost
11	Hirata, 1983	"	Monolithic MIC	4dB	
12	CCIR, 1982-86a(J)	"	GaAsFET MIC	2.5-3.0dB	BW=300MHz
13	CCIR,1986-90a(J)	12 GHz	HEMT	1.8 dB average	BW=300MHz
14	CCIR,1986-90b(J)	23 GHz	HEMT	5 dB	

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KONISHI, Y. [May, 1980] Satellite broadcasting receiver – present and future. IEEE MTT-S International Microwave Symposium, Washington, DC, USA.

CCIR documents

[1978-82]: a.10-11S/141 (USA); b. 10-11S/16 (France); c. 10-11S/62 (Japan)

[1982-86]: a.10-11S/137(Japan)

[1986-90]: a.10-11S/104(Japan) b. 10-11S/25 (Japan);

ANNEX VI

RESULTS OF THE FIELD EXPERIENCES FOR SATELLITE BROADCASTING CABLE DISTRIBUTION SYSTEM IN JAPAN

Operational satellite broadcasting in Japan commenced in 1984 using the BS-2 satellite. At the end of August 1989, about 800,000 households were receiving satellite broadcasting programmes employing either AM or FM cable distribution. FM distribution techniques have advantages of transmission quality for both picture and digitally modulated sound and data programmes. Approximately 8,000 installations using FM distribution techniques were operating at that time and this number is increasing.

Studies concerning satellite broadcasting signal distribution by cable were carried out several times at different phases of development in Japan. Results show that one of the possible significant impairments in cable distribution systems is a flicker disturbance relating to the 15 Hz dispersal signal due to the echo resulting from mismatches in cable connections. Theoretical analysis, as well as laboratory and field tests predicted these effects and help identify practicable limits for the echo amplitude due to cable mismatches.

Figure 5 shows the relationship between the echo amplitude ratio and delay time in an FM distribution system which gives just perceptible flicker impairment for different picture patterns (Curves A) and also gives bit error ratio for the digital signal for sound and data (Curve B). Lines C and D show calculated echo delay and amplitude ratio in the cable connection predicted by the indicated loss and VSWR. According to these results, it is considered that a permissible value of VSWR for cable connections will be between 1.5 and 2, as compared with 2.5 for the case of individual reception.

A possible cause of worst case echoes may be due to open or short circuit conditions at the tap-off terminal. To keep reflections at the connection points to a minimum, it is necessary to define a minimum value of isolation at the tap-off terminal. For example, preferred characteristics of a trunk line tap-off unit is a VSWR of less than 1.2, and isolation between trunk line and receiver port more than 14 dB.

Compared to the requirements of an AM distribution system for conventional television systems, FM distribution systems require less stringent characteristics for most parameters except for the above-mentioned echo characteristics. If sufficient bandwidth is available and components such as signal combiners, distribution amplifiers and dividers with appropriate characteristics are chosen, FM cable distribution systems can provide acceptable performance.

According to the above field experience , it is confirmed that there are no major problems of applying FM distribution techniques to cable distribution systems.

ANNEX VII

MEASUREMENT RESULTS ON BSS SIGNALS DISTRIBUTED IN COMMUNITY RECEIVING INSTALLATIONS

1. Laboratory tests in France

Laboratory tests have been carried out in France [CCIR, 1986-90a] on D2, D, C-MAC/packet signals, with the modulation parameters specified in those of Report 1073, using a satellite simulator with characteristics very close to TDF-1, in order to evaluate the impairments on both sound/data and vision components introduced by a single echo, of different levels, added to the direct signal at the second IF of 230 MHz. The echo delay was equal to the bit interval of each system, i.e. 100 nsec for D2 and 50 nsec for both C and D. The phase difference between direct and delayed signals was adjusted to cause maximum impairment.

The tests included a 2.5 MHz offset of the carrier frequency with respect to the receiving filter, which corresponds to the operation of an AFC circuit based on the average picture content. For the C type signals both frequency demodulation by limiter/discriminator and 2-4 PSK differential demodulation were adopted.

The impairments on the sound/data component were measured in terms of C/N ratios, in 27 MHz, corresponding to a bit error ratio of 1×10^{-3}. For the MAC vision component the impairment was expressed by the decompressed luminance S/N ratio, using weighting network given in Recommendation 567-2 (1982).

2. Laboratory tests in Italy

In the experimental investigations carried out in Italy [Cominetti and Stroppiana, 1986]; [CCIR, 1986-90b] the C-MAC/packet signals were injected into the distribution network shown in Figure 7, which was laboratory implemented. This type of network structure, frequently found in existing installations, uses resistive dividers not perfectly matched to the main line, which are responsible for multiple reflections moving towards the head-end unit. The maximum impairments, due to the alterations of the amplitude and group-delay/frequency responses, were therefore measured at the fifth floor outlets.

Better matching would be achievable by adopting directional coupler dividers, generally used only in new installations. In order to assess the maximum expected impairments with respect to the ideal matching condition, in terms of C/N ratios, in 27 MHz, for a bit error ratio of 1×10^{-3} on the sound/data component, and in terms of C/N variations for the vision component, the carrier frequency was initially set to f_0 = 387 MHz, where significant irregularities affected the frequency response; and then offset step-by-step in the range of ± 10 MHz.

REFERENCES

COMINETTI, M., STROPPIANA, M. [November 1986] - Distribution of DBS signals of the MAC-family in collective antenna systems", Third International Conference on New Systems and Services in Telecommunication, Liége.

CCIR Documents

[1986-90]: a. 10-11S/56 (France); b. 10-11S/34 (Italy).

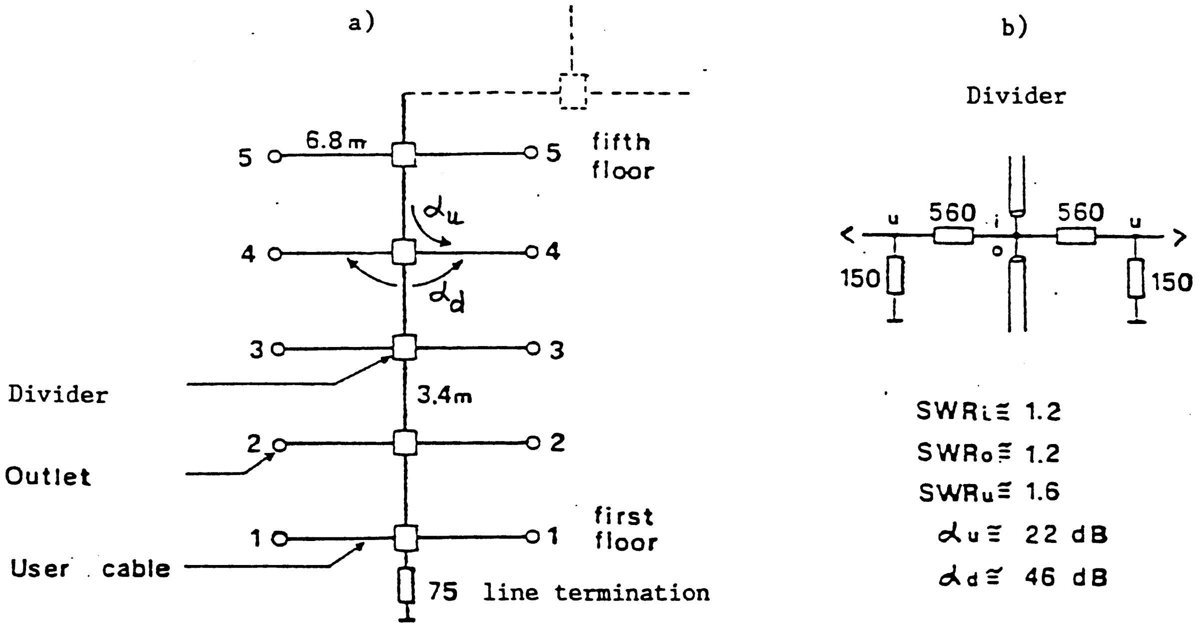

FIGURE 7

a) Typical distribution network used in small community antenna systems and adopted in the laboratory tests

b) Structure and characteristics of the user divider

ANNEX VIII

[CCIR, 1978-82a]

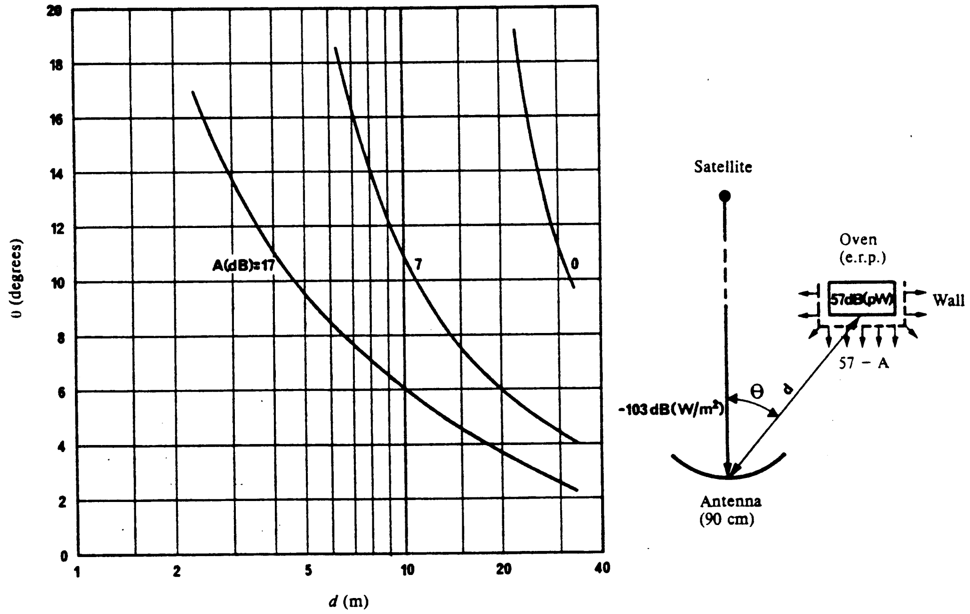

FIGURE 8 – *Limitation on the location of a receiver against the 5th harmonic radiation of a microwave oven including the shielding loss (A) due to the wall*
(*C/I* = 30 dB)

REFERENCES

CCIR Documents

[1978-82]: **a.** 10-11S/113 (Japan).