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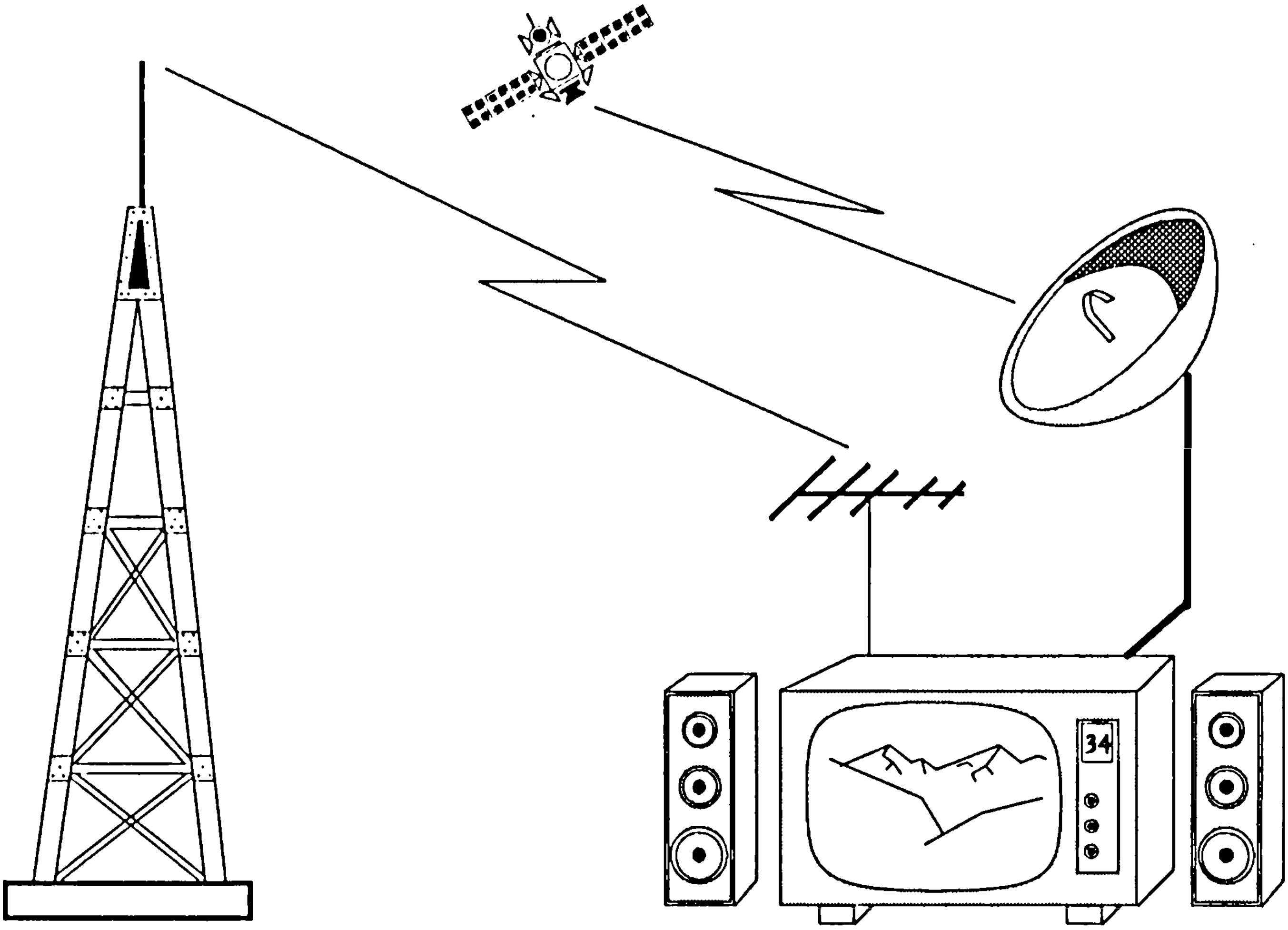

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BROADCASTING SERVICE (TELEVISION)

CCIR

INTERNATIONAL RADIO CONSULTATIVE COMMITTEE

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Recommendation 655-2 (1992)

Radio-frequency protection ratios for AM vestigial sideband television systems

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RECOMMENDATION 655-2

RADIO-FREQUENCY PROTECTION RATIOS FOR AM VESTIGIAL SIDEBAND TELEVISION SYSTEMS

(Question 4/11)

(1986-1990-1992)

The CCIR

recommends

that the protection ratios given in this Recommendation should be used for planning purposes.

Studies are still required to allow completion of information on protection ratios applicable to:

- data signals,
- sound signals,
- out-of-channel response,
- within-channel response above the video range,
- 525-line systems,
- system B in the UHF range,
- synchronized carrier operation.

1. Introduction

The RF protection ratio is the minimum value of wanted-to-unwanted signal ratio, usually expressed in decibels at the receiver input, determined under specified conditions such that a specific reception quality is achieved at the receiver output.

1.1 The values of protection ratio quoted apply to interference produced by a single source. Except where otherwise stated, the ratios apply to tropospheric (*T*) interference and correspond closely to a slightly annoying impairment condition. They are considered to be acceptable only if the interference occurs for a small percentage of the time, not precisely defined but generally considered to be between 1% and 10%. For substantially non-fading unwanted signals, it is necessary to provide a higher degree of protection and ratios appropriate to continuous (*C*) interference should be used (see Annex 1). If the latter are not known, then the tropospheric (*T*) values increased by 10 dB can be applied.

Values applicable to limit of perceptibility (*LP*) are given for information only.

1.2 Significantly strong wanted input signals can require higher protection ratio because of non-linear effects in the receiver.

1.3 For 625-line systems, the reference impairment levels are those which correspond to co-channel protection ratios of 30 dB and 40 dB with a frequency-offset between vision carriers close to two-thirds of the line frequency but adjusted for maximum impairment, the precise frequency difference being 10.416 kHz. These conditions approximate to impairment grades 3 (slightly annoying) and 4 (perceptible but not annoying) and respectively apply to tropospheric (*T*) and continuous (*C*) interference.

1.4 It should be noted that the amplitude of a vision-modulated signal is defined as the r.m.s. value of the carrier at peaks of the modulation envelope (taking no account of the chrominance signal in positive-modulation systems), while that of a sound-modulated signal is the r.m.s. value of the unmodulated carrier, both for amplitude modulation and for frequency modulation.

For planning purposes it may be assumed that the power in the chrominance channel does not exceed a value which is 16 dB lower than the power in the vision carrier during peaks of the modulation envelope.

1.5 The protection ratio values are not affected if digital data are included in the field-blanking interval of the unwanted television signal. However, certain values are affected in the case of a full-field data unwanted signal; in particular, it is not possible to achieve the full advantages of precision offset operation.

1.6 The relationship between the vision carrier frequencies of the wanted and unwanted signal is as follows (see Annex 2):

1.6.1 ***Non-controlled condition***

No special control of the nominal frequency difference between the carriers of the wanted and unwanted signals.

1.6.2 ***Non-precision offset***

Difference between the nominal frequencies of the wanted and unwanted carriers is suitably related to the line frequency, the tolerance of the carrier frequencies being ± 500 Hz.

The line synchronization of television receivers must be sufficiently immune to periodic interference if full advantage of carrier offset operation is to be achieved.

1.6.3 **Precision offset** (see Annex 3)

Difference between the nominal frequencies of the wanted and unwanted carriers is suitably related to the line and field frequencies, but with a tolerance of each of the nominal carrier frequencies of the order of ± 1 Hz and stability of the line frequencies equal to or better than 1×10^{-6}. In order to take full advantage of precision offset when the interfering carrier falls in the upper video range (greater than 2 MHz) of the wanted signal, a line-frequency stability of at least 2×10^{-7} is necessary.

Note 1 – In many cases, particularly with precision offsets, the required sound protection ratio can be higher than the ratio required between the vision signals. In such instances increasing the frequency offset by a suitable multiple of one, two or three lines frequency will decrease the required sound protection ratio by more than 10 dB, the vision protection ratio remaining unchanged.

2. Co-channel Interference

In this section, the protection ratios between two television signals apply only for interference due to the modulated vision carrier of the unwanted signal. Additional protection may be necessary if the wanted sound carrier is affected, or if the unwanted sound carrier lies within the wanted vision channel (e.g. the unwanted sound carrier of system G lies within the vision channel of system K). For all protection ratio figures in this section, the following corrections have to be made:

When the wanted signal is modulated negatively and the unwanted signal is modulated positively (L/SECAM), the values should be increased by 2 dB.

When the wanted signal is modulated positively and the unwanted signal is modulated negatively, the values should be reduced by 2 dB.

Correction is not necessary if the wanted and unwanted signals have the same modulation polarity.

2.1 ***Carriers separated by less than 1 000 Hz, non-controlled systems having the same or different line-standard***

Protection ratio: 45 dB, tropospheric interference.

2.2 *Carriers separated by parts of the line frequency, systems having the same line-standard, non-precision offset*

TABLE 1

Protection ratio, tropospheric interference carrier separation up to about ± 36/12 (f_{line}) (about ± 50 kHz) where f_{line} = line frequency

Offset of line frequency	1/2, 3/2, 5/2, . . .	1/3, 2/3, 4/3, . . .
625-line system (dB)	27	30
525-line system (dB)	25	28

2.3 *625-line systems, carriers separated by multiples of a twelfth of the line frequency up to about ± 36/12 f_{line} (about ± 50 kHz)*

These protection ratio values do not necessarily apply for greater carrier separations.

TABLE 2

Protection ratio between 625-line systems

Offset (multiples of 1/12 line-frequency)		0	1	2	3	4	5	6	7	8	9	10	11	12
Non-precision offset Transmitter stability ± 500 Hz	Tropospheric interference	45	44	40	34	30	28	27	28	30	34	40	44	45
	Continuous interference	52	51	48	44	40	36	33	36	40	44	48	51	52
	Limit of perceptibility	61	60	57	54	50	45	42	45	50	54	57	60	61
Precision offset Transmitter stability ± 1 Hz	Tropospheric interference	32	34	30	26	22	22	24	22	22	26	30	34	38
	Continuous interference	36	38	34	30	27	27	30	27	27	30	34	38	42
	Limit of perceptibility	42	44	40	36	36	39	42	39	36	36	40	44	48

Limit of perceptibility – only for information.

(Value in the first column is only valid for the 0/12 case. All other values between 1/12 and 12/12 are the same by addition or subtraction of integral multiples of 12/12 up to ± 6/12.)

3. Adjacent-channel interference

The given protection ratios apply to tropospheric interference and are defined in terms of wanted and unwanted vision carrier levels. For continuous interference, the values should be increased by 10 dB.

Adjacent-channel protection ratios cannot be determined directly from the overlapping channel protection ratio curves shown in § 5 because for certain systems the values may be affected by special measures in the receiver, e.g. sound traps.

3.1 *Lower adjacent-channel interference*

The worst interference on the picture signal from another signal, using the same standard, results from the sound signal in the lower adjacent channel. However, some improvement in protection is achieved if the unwanted sound carrier and the wanted vision carrier are separated by an effective offset in the vicinity of an odd multiple of half line-frequency. This is particularly noticeable during periods without sound modulation when the improvement can be as much as 10 dB; with modulation, the improvement is only 2-3 dB.

Linear correction should be made to take into account vision-to-sound power ratios different from those assumed in the following sub-sections.

3.1.1 *VHF bands*

The figures below relate to the cases where the separation between the wanted vision carrier frequency and the unwanted sound carrier frequency is 1.5 MHz and the ratio between the unwanted vision and unwanted sound powers is 10 dB.

Protection ratio: for frequency-modulated sound carrier

- systems N and M: –13 dB
- all other systems: –9 dB

for amplitude-modulated sound carrier

- system L (vision-to-sound power ratio 10 dB): –8 dB

3.1.2 *UHF bands*

Protection ratio: for the 525-line systems in a 6 MHz channel: –13 dB

For the various 625-line systems for use in 8 MHz channels in the UHF bands, Table 3 gives the protection required by a signal of any system against a lower adjacent-channel signal of the same or any other standards, assuming a vision-to-sound power ratio of 10 dB for unwanted signals of every standard. A correction must be made for different vision-to-sound power ratios.

3.2 *Upper adjacent-channel interference – VHF and UHF bands*

Protection ratio: for system N: –10 dB

for systems D and K: –6 dB

for all other systems: –12 dB

4. Image-channel interference

The protection ratio required will depend on the intermediate frequency and image-channel rejection of the receiver, and on the type of unwanted signal falling in the image channel. It can be determined by subtracting the image rejection figure from the required protection ratio for overlapping channels. Table 4 shows this situation.

TABLE 3

Protection ratio from lower adjacent-channel interference (UHF bands) for 625-line systems

Wanted signal \ Unwanted signal	Protection ratio (dB)					
	G	H	I	D, K	K1	L
G	-9	-9	-9	-9	-9	-5
H	-9	-9	-9	+13	+13	+17
I	-9	-9	-9	+13	+13	+17
D, K	-9	-9	-9	-9	-9	-5
K1	-9	-9	-9	-9	-9	+17
L	-9	-9	0	-12	-12	-8

TABLE 4

Image-channel rejection

Image-channel rejection (dB)	VHF	UHF
Systems D, and K/SECAM	45	30
System D/PAL	45	40
System I		50
System M (Japan)	60	45
All other systems		40

Table 5 shows this situation for the UHF bands. The wanted vision channel can be affected by the unwanted vision carrier, by the unwanted sound carrier, or by both.

The image-channel protection ratios in Table 5 apply to tropospheric interference, and are defined in terms of wanted and unwanted vision carrier levels assuming a vision-to-sound power ratio of 10 dB for every standard. A correction must be made for different vision-to-sound power ratios. For continuous interference, the values should be increased by 10 dB.

5. Overlapping channel interference

All figures and tables in this section give protection ratios to be applied when a CW signal lies within the vision channel of the wanted transmission, the wanted vision signal being negatively modulated.

TABLE 5

Protection ratio from image-channel interference 625-line systems (UHF bands)

Wanted signal \ Unwanted signal	Protection ratio (dB)					Image channel	Remarks
	G, H	I	D, K	K1	L		
G	-1	-4	-11	-11	-7	N + 9	Interference from sound carrier
H	-1	-4	-9	-9	-5	N + 9	
I	-13	-10	-10	-10	-6	N + 9	
D, K	-1	-15	-12	-12	-6	N + 8	Interference from sound carrier
	+13	+13	+13	+13	+15	N + 9	Interference from vision carrier
K1	-1	0	-2	-2	+2	N - 9	Interference from sound carrier
	-1	-4	-5	-5	-1	N + 9	
	+7	+7	+7	+7	+9	N + 10	Interference from vision carrier
L	-2	-2	-4	-13	-9	N - 9	Interference from sound carrier
	< -20	< -20	< -20	< -20	< -20	N - 8	Interference from vision carrier

Corrections to be made for positively modulated wanted vision signals and for other types of potentially interfering signals are as given in Table 6.

When the unwanted signal is a television signal, two calculations of protection ratio are necessary: one for the unwanted vision carrier and one for the unwanted TV sound carrier. The protection ratios shown for unwanted frequency-modulated sound carriers do not apply to non-precision and precision offset conditions. Nevertheless, a reduction of 2 dB relative to the non-controlled condition (curves A and A′) is achieved for non-precision carriers with offsets within the luminance frequency range between 3/12 and 9/12 of the line frequency, and within the chrominance frequency range at 0/12, 1/12, 5/12, 6/12, 7/12, 11/12 and 12/12 of the line frequency.

5.1 525-line systems

Figure 1 and Table 7 show protection ratios for tropospheric interference. For continuous interference, the values should be increased by 10 dB. The unwanted signal is a CW carrier. For other types of unwanted signal, the given correction factors should be applied.

5.2 625-line systems

Figures 2 to 4 and Tables 8 to 10 give protection ratios applicable for tropospheric and continuous interference, and for limit of perceptibility. The values shown refer to the case of a wanted negatively modulated vision signal affected by an unwanted CW signal. The previously indicated corrections apply when considering other combinations of wanted and unwanted signals.

The curves shown in Figs. 2 to 4 are examples that can be derived directly from the associated tables. They illustrate the full range of protection ratio possibilities from the worst case of non-controlled condition (curves A and A′) to the best achievable using either non-precision offset (curves B and B′) or precision offset (curves C and C′). The curves A, B and C are related to the luminance frequency range, the curves A′, B′ and C′ to the chrominance frequency range for the PAL and SECAM systems. For frequency differences below −1.25 MHz or above 6 MHz, the protection ratio can be derived by linear extrapolation to the channel limit.

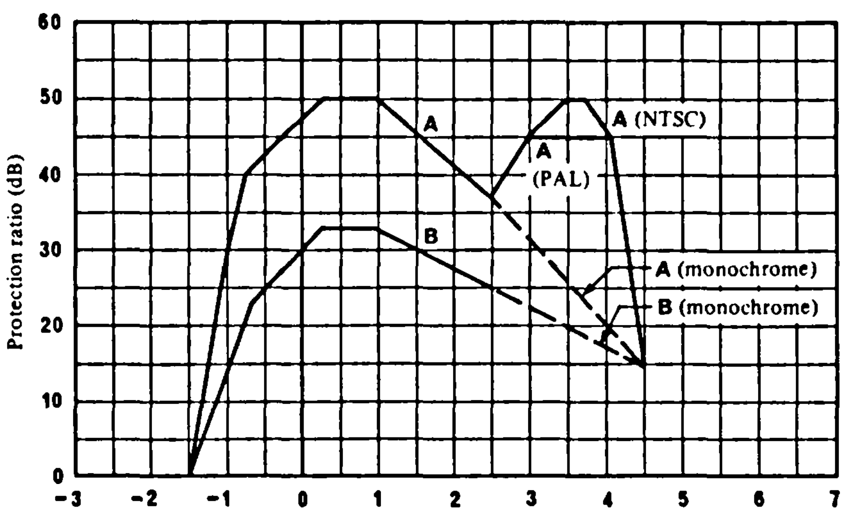
TABLE 6

Correction values for different wanted and unwanted signals

Wanted signal \ Unwanted signal	Correction factors (dB)				
	CW	TV-negative	TV-positive	FM-sound	AM-sound
Vision signal negative modulated	0	–2	0	0	+4
Vision signal positive modulated	–2	–4	–2	–2	+2

FIGURE 1 and TABLE 7

525-line systems (M/NTSC and M/PAL)
Tropospheric interference. Unwanted signal: CW carrier

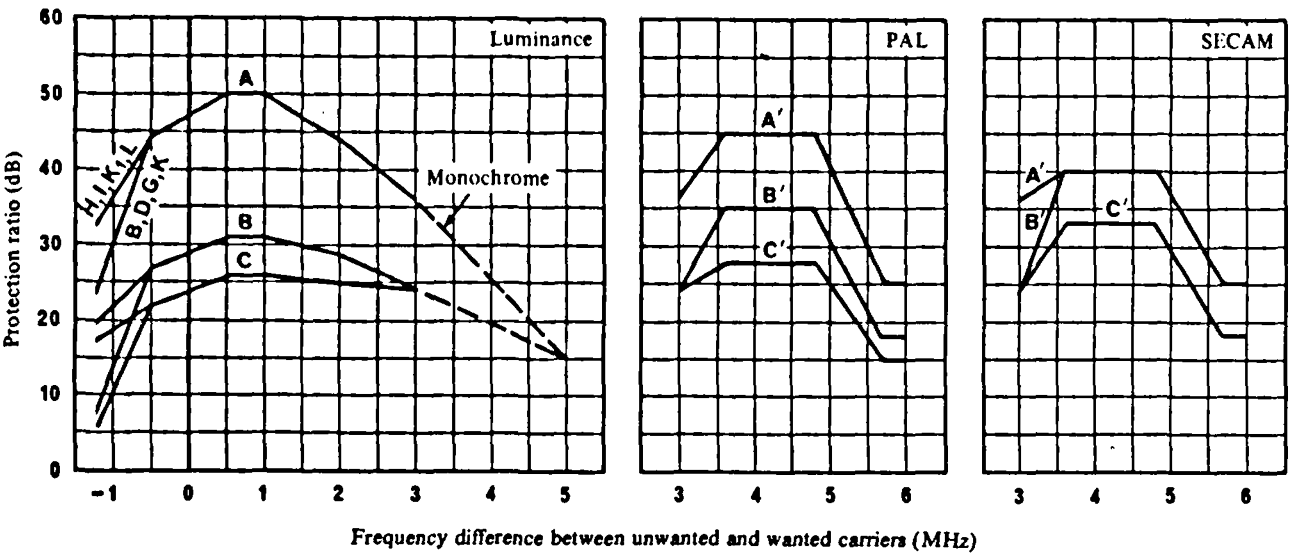


<table>
<tr><td colspan="2">Frequency difference (MHz)</td><td>–1.5</td><td>–1.0</td><td>–0.75</td><td>0.3</td><td>1.0</td><td>2.5</td><td>3.0</td><td>3.5</td><td>3.7</td><td>4.1</td><td>4.5</td></tr>
<tr><td>A</td><td>NTSC (dB)</td><td rowspan="3">0</td><td rowspan="3">30</td><td rowspan="3">40</td><td rowspan="3">50</td><td rowspan="3">50</td><td rowspan="3">37</td><td rowspan="3">45</td><td>50</td><td>50</td><td rowspan="2">45</td><td rowspan="3">15</td></tr>
<tr><td>A</td><td>PAL (dB)</td><td>45</td><td>45</td></tr>
<tr><td>A</td><td>Monochrome (dB)</td><td></td><td></td><td></td></tr>
<tr><td>B</td><td>Monochrome (dB)</td><td>0</td><td>15</td><td></td><td>33</td><td>33</td><td>25</td><td colspan="4"></td><td>15</td></tr>
<tr><td colspan="13">Protection ratio (dB)</td></tr>
</table>

Curves A: non controlled condition
B: non-precision offset condition
(1/3, 2/3, 4/3, 5/3, all of the line frequency)

FIGURE 2 and TABLE 8

625-line systems. Tropospheric interference



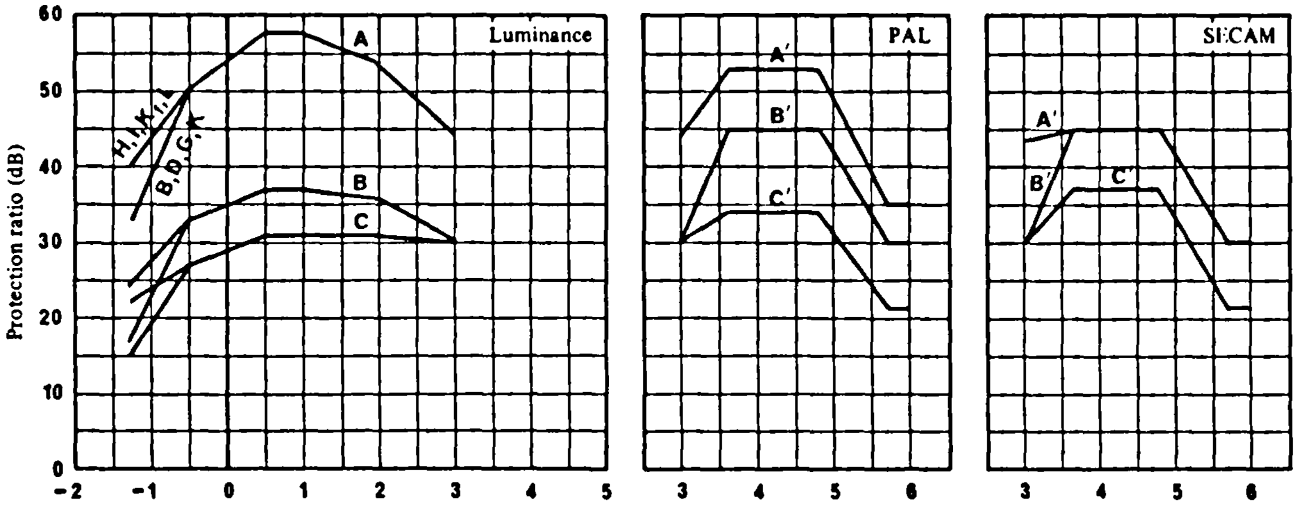
Offset (multiples of 1/12 line-frequency)		Curve	Frequency difference between unwanted and wanted carriers (MHz)											
			Luminance range								PAL		SECAM	
			-1.25(1)	-1.25(2)	-0.5	0.0	0.5	1.0	2.0	3.0	3.6-4.8	5.7-6.0(3)	3.6-4.8(4)	5.7-6.0(3)
0	NO	A,B'	**32**	**23**	**44**	**47**	**50**	**50**	**44**	**36**	**35**	**18**	**40**	**25**
	PO	C'	23	11	32	34	40	40	37	31	**28**	**15**	**33**	**18**
1	NO		31	20	43	46	49	49	42	34	39	20	40	25
	PO		23	11	33	36	39	39	36	31	31	16	33	18
2	NO		28	17	39	42	45	45	39	32	42	22	40	25
	PO		21	9	29	32	35	35	33	29	34	17	33	18
3	NO	A'	25	13	34	36	39	39	35	29	**45**	**25**	**40**	**25**
	PO	B'	19	7	25	28	31	31	29	26	**35**	**18**	**33**	**18**
4	NO		22	10	30	32	35	35	32	27	42	22	40	25
	PO	C	**17**	**5**	**22**	**24**	**26**	**26**	**25**	**24**	34	17	33	18
5	NO		20	8	28	30	32	32	30	25	39	20	40	25
	PO	C	**17**	**5**	**22**	**24**	**26**	**26**	**25**	**24**	31	16	33	18
6	NO	B,B'	**19**	**7**	**27**	**29**	**31**	**31**	**29**	**24**	**35**	**18**	**40**	**25**
	PO	C'	17	5	24	26	28	28	26	24	**28**	**15**	**33**	**18**
7	NO	B'	20	8	28	30	32	32	30	25	**35**	**18**	**40**	**25**
	PO	C,C'	**17**	**5**	**22**	**24**	**26**	**26**	**25**	**24**	**28**	**15**	**33**	**18**
8	NO		22	10	30	32	35	35	32	27	39	20	40	25
	PO	C	**17**	**5**	**22**	**24**	**26**	**26**	**25**	**24**	31	16	33	18
9	NO		25	13	34	36	39	39	35	29	42	22	40	25
	PO		19	7	25	28	31	31	29	26	34	17	33	18
10	NO		28	17	39	42	45	45	39	32	39	20	40	25
	PO		21	9	29	32	35	35	33	29	31	16	33	18
11	NO	B'	31	20	43	46	49	49	42	34	**35**	**18**	**40**	**25**
	PO	C'	23	11	33	36	39	39	36	31	**28**	**15**	**33**	**18**
12	NO	A,B'	**32**	**23**	**44**	**47**	**50**	**50**	**44**	**36**	**35**	**18**	**40**	**25**
	PO	C'	23	11	32	40	40	40	37	31	**28**	**15**	**33**	**18**
			Protection ratio (dB)											

(1) H, I, K1, L television systems.
(2) B, D, G, K television systems.
(3) B, G television systems: range is 5.3-6.0 MHz.
(4) D/SECAM and K/SECAM: add 5 dB.

NO: non-precision offset
PO: precision offset

FIGURE 3 and TABLE 9

625-line systems. Continuous interference



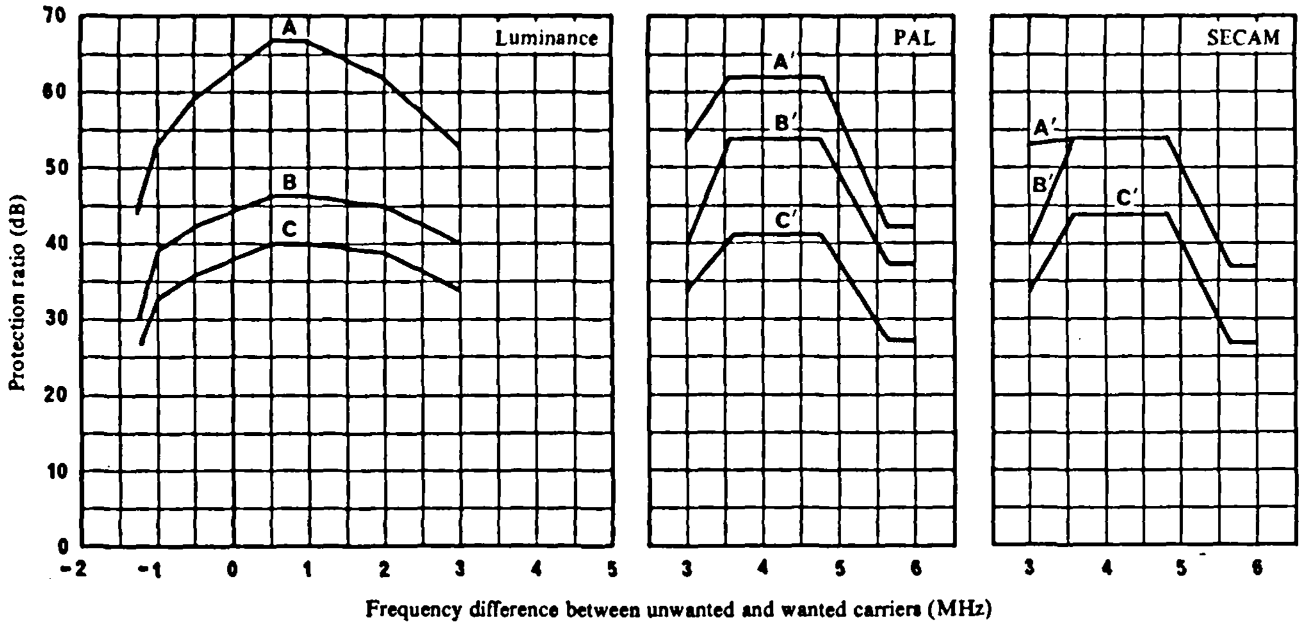
Offset (multiples of 1/12 line-frequency)		Curve	Frequency difference between unwanted and wanted carriers (MHz)											
			Luminance range								PAL		SECAM	
			-1.25(1)	-1.25(2)	-0.5	0.0	0.5	1.0	2.0	3.0	3.6-4.8	5.7-6.0(3)	3.6-4.8(4)	5.7-6.0(3)
0	NO	A,B'	40	32	50	54	58	58	54	44	45	30	45	30
	PO	C'	30	22	37	38	44	44	42	36	34	21	37	21
1	NO		38	30	49	53	57	57	53	43	48	32	45	30
	PO		29	22	38	40	42	42	41	36	36	22	37	21
2	NO		34	27	46	50	55	55	51	41	51	33	45	30
	PO		27	20	34	36	38	38	37	34	39	24	37	21
3	NO	A'	30	23	42	46	50	50	46	38	53	35	45	30
	PO		24	17	30	32	34	34	33	31	40	26	37	21
4	NO		28	21	38	42	45	45	42	35	51	33	45	30
	PO	C	22	15	27	29	31	31	31	30	39	24	37	21
5	NO		26	19	35	38	41	41	38	32	48	32	45	30
	PO	C	22	15	27	29	31	31	31	30	36	22	37	21
6	NO	B,B'	24	17	33	35	37	37	36	30	45	30	45	30
	PO	C'	23	16	29	32	33	33	32	30	34	21	37	21
7	NO	B'	26	19	35	38	41	41	38	32	45	30	45	30
	PO	C,C'	22	15	27	29	31	31	31	30	34	21	37	21
8	NO		28	21	38	42	45	45	42	35	48	32	45	30
	PO	C	22	15	27	29	31	31	31	30	36	22	37	21
9	NO		30	23	42	46	50	50	46	38	51	33	45	30
	PO		24	17	30	32	34	34	33	31	39	24	37	21
10	NO		34	27	46	50	55	55	51	41	48	32	45	30
	PO		27	20	34	36	38	38	37	34	36	22	37	21
11	NO	B'	38	30	49	53	57	57	53	43	45	30	45	30
	PO	C'	29	22	38	40	42	42	41	36	34	21	37	21
12	NO	A,B'	40	32	50	54	58	58	54	44	45	30	45	30
	PO	C'	30	22	37	44	44	44	42	36	34	21	37	21
			Protection ratio (dB)											

(1) H, I, K1, L television systems.
(2) B, D, G, K television systems.
(3) B, G television systems: range is 5.3-6.0 MHz.
(4) D/SECAM and K/SECAM: add 8 dB.

NO: non-precision offset
PO: precision offset

FIGURE 4 and TABLE 10

625-line systems
Limit of perceptibility (for information only)



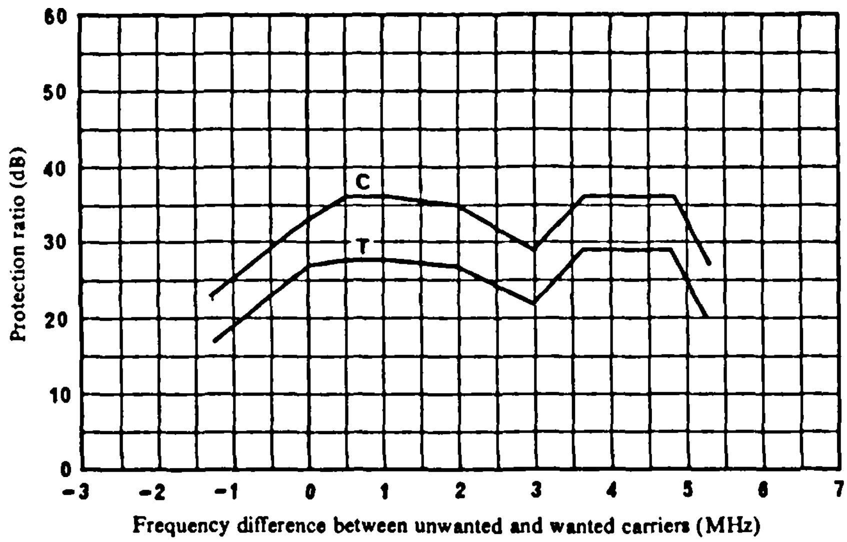
Frequency difference (MHz)		-1.25	-1.0	-0.5	0.0	0.5	1.0	2.0	3.0	3.6	4.8	5.7
A	PAL	44	53	59	63	67	67	62	53	62	62	42
	SECAM									54	54	37
B	PAL	30	39	42	44	46	46	45	40	54	54	37
	SECAM											
C	PAL	26	33	36	38	40	40	39	34	41	41	27
	SECAM									44	44	
Limit of perceptibility (dB)												

5.3 *Television signal affected by data signals*

The inclusion of digital data such as teletext in the field-blanking interval has no effect on the required protection ratios. However, the full improvement resulting from non-precision or precision offset operation is not achievable when the unwanted signal carries a full-field data signal. In this case, Fig. 5 shows the minimum values for all offset and non-offset conditions given in § 5.2. The curves in Fig. 5 apply to full-field data signals with pulse amplitude at 66% of the peak white-to-blanking level. The values should be increased linearly for higher modulation levels.

FIGURE 5 and TABLE 11

625-line systems – B/PAL and G/PAL
Protection from full-field data signals



Frequency difference (MHz)	–1.25	0.0	0.5	1.0	2.0	3.0	3.6	4.8	5.25
Tropospheric interference (*T*)	17	27	28	28	27	22	29	29	20
Continuous interference (*C*)	23	33	36	36	35	29	36	36	27
Protection ratio (dB)									

5.4 Television signal affected by a digital sound carrier

When digital sound is introduced on System B, at a level of –20 dB relative to the vision carrier, interference to D-SECAM is not increased provided that the existing System B FM sound carrier is reduced from –10 to –13 dB relative to the vision carrier. However, further studies on this and other similar cases are needed.

6. Protection ratio for sound signals

Protection ratios applicable to the wanted sound signal are given in Table 12 for both tropospheric and continuous interference. The values quoted refer to the level of the wanted sound carrier. In the case of a two-sound carrier transmission, each sound carrier must be separately considered. Multiplex modulated sound signals may require higher protection.

For an unwanted vision carrier, subtract 2 dB; for an unwanted amplitude-modulated sound carrier, add 4 dB.

The maximum deviation of the wanted FM sound carrier is assumed to be ±50 kHz. A linear correction should be made for other deviations.

Tables 12 and 13 give values of protection ratio where the television sound is affected by a single unwanted signal within the range ±250 kHz of the wanted sound carrier. In a co-channel situation the unwanted sound directly affects the wanted sound. In addition, the unwanted vision carrier produces phase modulation of the wanted vision carrier resulting in some sound distortion in receivers using inter-carrier demodulation techniques.

Improvement of the sound protection ratio can be reached by increasing the frequency offset by a suitable multiple of one, two or three lines frequency (see Note 1 in § 1.6.3).

The weighted signal-to-noise ratio will be improved by approximately 8 dB if, for example, 5/3 line-frequency offset is used instead of 2/3 line-frequency offset.

TABLE 12

Protection ratio for wanted sound carriers
Unwanted signal: CW or FM sound carrier

Difference between wanted sound carrier and unwanted carrier (kHz)	Wanted sound signal			
	Tropospheric interference		Continuous interference	
	FM	AM	FM	AM
0	32	49	39	56
15	30	40	35	50
50	22	10	24	15
250	–6	7	–6	12
	Protection ratio (dB)			

TABLE 13

Sound carrier protection ratios (dB)

Wanted \ Unwanted		FM/CW	AM	Digital
FM	*T*	32	36 (1)	
	C	39	43 (1)	
AM	*T*	49	53 (1)	37
	C	56	60 (1)	44
Digital	*T*		12	12
	C		13	13

(1) Values are 4 dB higher than those in the first column.

Note 1 – In the case of interference from an I/PAL signal with digital sound to an L-SECAM signal, the full benefit of precision offset may not be obtained because of interference to the AM sound signal.

The reference sound quality is grade 3 for tropospheric interference and grade 4 for continuous interference.

Reference signal-to-noise ratios (S/N) for sound analogue signals, where S/N is peak-to-peak weighted (see Recommendation 468):

- 40 dB (approximates to impairment grade 3 (T))
- 48 dB (approximates to impairment grade 4 (C)).

Reference bit error ratios for digital sound signals:

- 10^{-4} (approximates to impairment grade 3 (T))
- 10^{-5} (approximates to impairment grade 4 (C)).

7. Synchronized carrier operation

Field and laboratory tests have demonstrated that synchronized carrier television systems allow a similar reduction in co-channel interference to that achieved by use of precision offset techniques, when the same television programme is transmitted. Ratios of wanted-to-unwanted signals of 28 dB and 38 dB were respectively found to correspond to impairment grades of 3.5 and 4.5.

No degradation of picture quality was observed when the frequency difference between both vision carriers was less than 0.2 Hz and/or the phase fluctuations were less than 20°.

The use of synchronized carrier techniques simplifies the introduction of new television transmitters and transposers into existing networks.

Further studies in this field are required, especially for the case of different television programmes.

ANNEX 1

Tropospheric and continuous interference

When using the protection ratios in planning, it is necessary to determine whether, in the particular circumstances, the interference should be considered as tropospheric or continuous. This can be done by comparing the nuisance fields for the two conditions, the nuisance field being defined as the field strength of the interfering transmitter (at its pertinent e.r.p.) enlarged by the relevant protection ratio.

Thus, the nuisance field for continuous interference:

$$E_C = E(50, 50) + P + A_C$$

and the nuisance field for tropospheric interference:

$$E_T = E(50, t) + P + A_T$$

where:

$E(50, t)$: field strength (dB(μV/m)) of the interfering transmitter, normalized to 1 kW, and exceeded during t% of the time

P : e.r.p. (dB(1 kW)) of the interfering transmitter

A : protection ratio (dB)

and where the indices C and T indicate continuous and tropospheric interference, respectively.

The protection ratio for continuous interference is applicable when the resulting nuisance field is stronger than that resulting from tropospheric interference, that is, when $E_C > E_T$.

This means that A_C should be used in all cases when:

$$E(50, 50) + A_C > E(50, t) + A_T$$

ANNEX 2

Different offset conditions

The required protection ratio varies considerably depending on the frequency relationship between the wanted and the unwanted carriers and their frequency tolerance. The greatest protection is required when the frequency of one or both carriers is "non-controlled".

Less interference is possible and therefore lower protection ratios are required for non-precision offset (line frequency offset). Non-precision offset takes advantage of the line frequency structure of the video signal and, in particular, it is advantageous to offset the carriers by multiples of one-half or one-third of the line frequency. The long-term stability of these favourable protection ratios can only be guaranteed, however, if the frequencies of the wanted and unwanted signals are kept constant within ± 500 Hz.

Precision offset takes further advantage of the field frequency structure of the video spectrum. The least protection is required when both carriers are "precision offset" controlled within a tolerance of ± 1 Hz for the wanted and unwanted carriers.

Figure 6 shows the main characteristics of offset operation and plots in schematic form the protection ratio curves between 0/12 f_{line} and 12/12 f_{line}. These curves are cyclic and their extensions to the left and right are symbolized by broken lines. These various conditions illustrated are similar within the luminance range up to about ± 3 MHz.

The upper and lower curves indicate, respectively, the protection ratios obtained with non-precision and precision offset. More precisely, these two curves trace the envelope of a series of fluctuations in the protection ratio which swings between the two curves at field frequency as represented by the thin line.

Co-channel protection ratio curves in the vicinity of 0/12, 4/12, and 6/12 line frequency (625-line systems)

Figure 7 gives examples of protection ratio curves for the three most important offset positions (0/12, 4/12 and 6/12 f_{line}). The curves in each graph relate to tropospheric interference, continuous interference and the limit of perceptibility.

The white and black points indicate the positions for non-precision and precision offset respectively. The reference impairment points for tropospheric and continuous interference are also indicated in the figure.

When operating TV transmitter networks with synchronized as well as phase-locked carriers, the protection ratio values are slightly reduced.

FIGURE 6

Schematic protection ratio curves with different offset positions

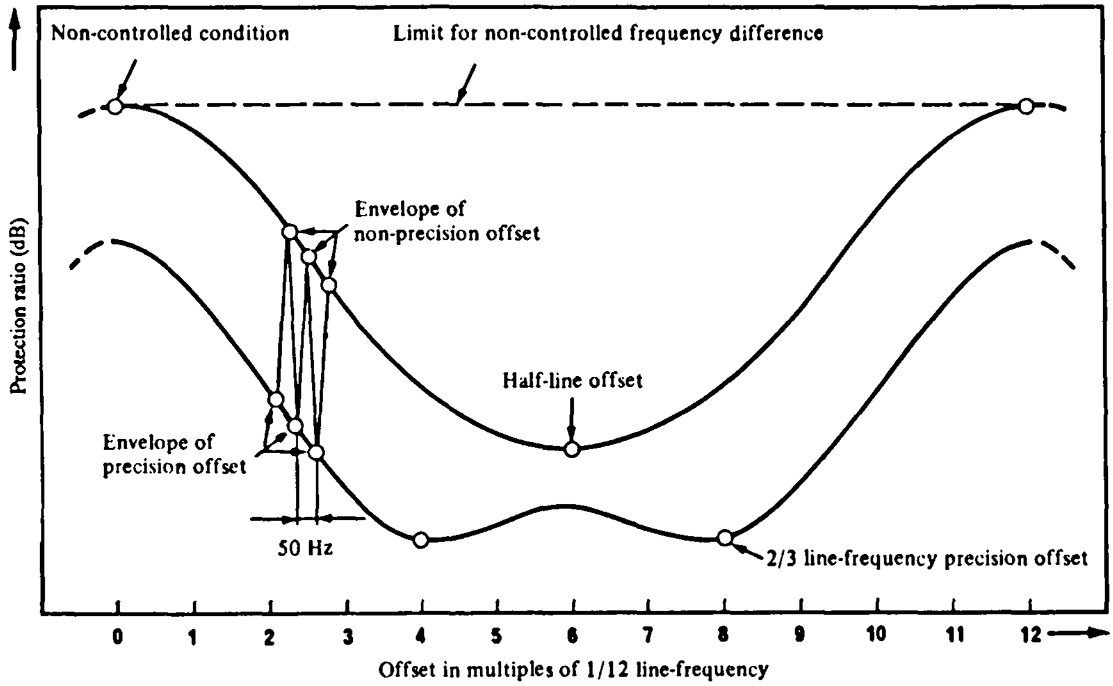
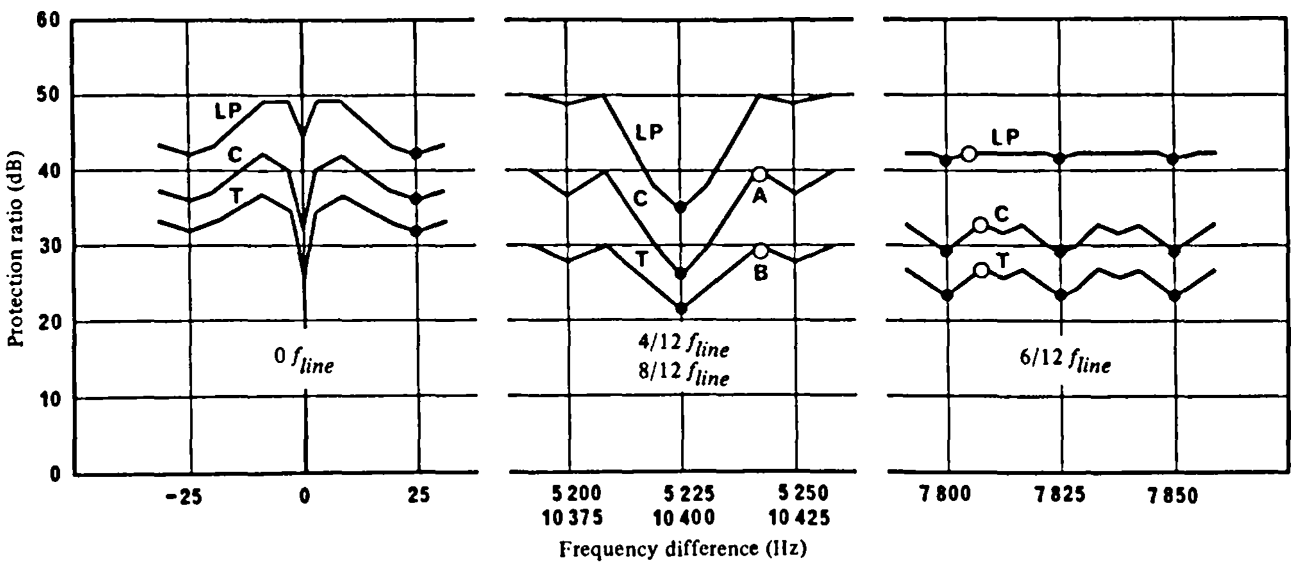


FIGURE 7

Precise structure of the protection ratio curves for different offset positions



Curves T: tropospheric interference
C: continuous interference
LP: limit of perceptibility
A: continuous interference reference point
B: tropospheric interference reference point

○ Non-precision offset
● Precision offset

ANNEX 3

Frequencies for precision offset

Table 14 lists the possible frequencies for precision offset in the vicinity of each twelfth of line frequency. For the luminance frequency range, the frequencies shown in the table end with 25 Hz up to $6/12\, f_{line}$ and with 100 Hz beyond this frequency. Two possibilities are shown for $6/12\, f_{line}$ (7 800 and 7 825 Hz) because at this point the spectral lines are symmetrical and thus of the same amplitude. The offset frequencies are expressed in twelfths of line frequency.

Alternative frequencies in the vicinity of each offset position, which differ by integer multiples of 50 Hz and by integral multiples of 15 625 Hz from the values given, are possible. The term "precision offset" always refers to a difference between the true frequencies of the wanted and unwanted transmitters, and not to an offset of a transmitter from its nominal carrier frequency.

If the frequency difference between wanted and unwanted carrier exceeds the normalized range specified in Table 14, one has to subtract integral multiples of 15 625 Hz. For computer calculations, formulae are given below for all precision-offset frequency differences in the luminance and in the chrominance range for 625-line systems.

TABLE 14

Normalized precision offset between 0/12 and 12/12 of line frequency

Luminance range: for all 625-line systems
Chrominance range: only PAL and SECAM systems

Offset (multiples of 1/12 line-frequency)	Precision offset frequency (Hz)		
	Luminance range	Chrominance range	
		PAL	SECAM
0	25	5	0
1	1 325	1 305	1 302
2	2 625	2 605	2 604
3	3 925	3 905	3 906
4	5 225	5 205	5 208
5	6 525	6 505	6 510
6	7 800 or 7 825	7 810	7 812
7	9 100	9 115	9 115
8	10 400	10 420	10 417
9	11 700	11 720	11 719
10	13 000	13 020	13 021
11	14 300	14 320	14 323
12	15 600	15 630	15 625

Luminance range:

$$f_p = m \times 15\,625 \pm (2n + 1) \times 25$$
$m \leq 192,\ n \leq 156$

Chrominance range:

– *PAL systems*

$$f_p = m \times 15\,625 \pm (2n + 1) \times 25 + k$$

$m \geq 216$ and
$k = -20$ for $0 \leq n < 143$
$k = -15$ for $143 \leq n < 169$
$k = -5$ for $169 \leq n < 299$
$k = +5$ for $299 \leq n \leq 312$

– *SECAM systems*

$$f_p = m \times 15\,625 + 2n \times \left(25 + \frac{25}{624}\right)$$

with m, n, k integers

Computation of operational offset frequencies in a network with transmitter triplets

Precision offset techniques are usually introduced to provide solutions of particular interference problems between two co-channel transmitters. In operational television networks, co-channel transmitters are situated at the corner of a triangle. A typical line offset (non-precision offset) situation for such a transmitter triplet is: nominal vision carrier frequency $-2/3\ f_{line}$, $\pm 0\ f_{line}$ and $+2/3\ f_{line}$ or in twelfths: 8M, 0, 8P (M = minus; P = plus). A transmitter triplet A-B-C consists of three transmitter pairs A-B, A-C and B-C. Introduction of precision offset for the above-mentioned example means a possible reduction of interference for all three pairs of the transmitter triplet. In practice, only 35% of all the theoretically possible transmitter triplets have full improvement for all three pairs, the residual 65% triplets have one or two pairs in non-precision offset.

Table 15 shows a complete and normalized list of these 35% possible cases within the range between 0P and 12P which secure an improved interference situation for all three transmitter pairs within a triplet, when precision offset is used.

With a simple rule, determination of precision offset frequencies for transmitter triplets is possible. All transmitter triplets which cannot translate to the normalized cases of Table 15 contain at least one pair without precision offset.

Example

The aim of this calculation is the transformation of all three offset positions into the range between 0P and 12P (see Table 15). Each single transmitter can be moved by multiples of line frequency, that means by multiples of 12/12 (see Step 2). Moving of any twelfths is allowed, when all transmitters are moved by the same number of twelfths (see Step 1).

	A	B	C
Given: Transmitter triplet line offset position:	18M	8P	2P
Step 1			
Set one transmitter to 0 by linear translation:	+18	+18	+18
Result:	0	26P	20P
Step 2 Translation of transmitter B and C into the range between 0P and 12P by subtracting or adding multiple of the line frequency:		−24	−12
Result:	0	2P	8P
Step 3 Selection of precision offset frequencies from Table 15:	0	2625	10400 Hz
Step 4 Step 2 has to be compensated:		+31250	+15625 Hz
Result:	0	+33875	+26025 Hz
Step 5 Step 1 has to be compensated:	−23400	−23400	−23400 Hz
Result:	−23400	+10475	+ 2625 Hz
equivalent to	18M	8P*	2P

* To reduce the sound interference between transmitter B and C, an offset position of 20P = 26 100 Hz (enlarged by 12P = 15 625 Hz) would be preferable. In this case picture interference is unchanged.

TABLE 15

Possible offset combinations allowing precision offset for all transmitter pairs in transmitter triplets

Case	Offset			Frequency (Hz) (625-line systems)		
1	0	0P	6P	0	25	7 800
2	0	0P	6P	0	25	7 825
3	0	1P	6P	0	1 325	7 800
4	0	1P	7P	0	1 325	9 100
5	0	2P	6P	0	2 625	7 800
6	0	2P	7P	0	2 625	9 100
7	0	2P	8P	0	2 625	10 400
8	0	3P	6P	0	3 925	7 800
9	0	3P	7P	0	3 925	9 100
10	0	3P	8P	0	3 925	10 400
11	0	3P	9P	0	3 925	11 700
12	0	4P	6P	0	5 225	7 800
13	0	4P	7P	0	5 225	9 100
14	0	4P	8P	0	5 225	10 400
15	0	4P	9P	0	5 225	11 700
16	0	4P	10P	0	5 225	13 000
17	0	5P	6P	0	6 525	7 800
18	0	5P	7P	0	6 525	9 100
19	0	5P	8P	0	6 525	10 400
20	0	5P	9P	0	6 525	11 700
21	0	5P	10P	0	6 525	13 000
22	0	5P	11P	0	6 525	14 300
23	0	6P	6P	0	7 800	7 825
24	0	6P	7P	0	7 825	9 100
25	0	6P	8P	0	7 825	10 400
26	0	6P	9P	0	7 825	11 700
27	0	6P	10P	0	7 825	13 000
28	0	6P	11P	0	7 825	14 300
29	0	6P	12P	0	7 800	15 600
30	0	6P	12P	0	7 825	15 600