BROADCAST ENGINEER'S HANDBOOK

A collection of useful reference data
for TV broadcasting engineers

ABE ELETTRONICA S.p.A.

Via Leonardo da Vinci, 92 - 24043 CARAVAGGIO (BG), Italy

Tel. +39-0363-351007, Fax +39-0363-50756

WEB SITE: http://www.abe.it E-mail: mail@abe.it

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VHF Channel definitions

BAND	CHANNEL	CHANNEL LIMITS (MHZ)	VISION CARRIER	SOUND CARRIER
Standard B (7 Mhz), Australia				
IF	-	33.15 to 40.15	38.9	33.4
I	0	45 to 52	46.25	51.75
	1	56 to 63	57.25	62.75
	2	63 to 70	64.25	69.75
(II)	3	85 to 92	86.25	91.75
	4	94 to 101	95.25	100.75
	5	101 to 108	102.25	107.75
	5A	137 to 144	138.25	143.25
III	6	174 to 181	175.25	180.75
	7	181 to 188	182.25	187.75
	8	188 to 195	189.25	194.75
	9	195 to 202	196.25	201.75
	10	208 to 215	209.25	214.75
	11	215 to 222	216.25	221.75
Standard B (7 Mhz), Europe				
IF	-	33.15 to 40.15	38.9	33.4
I	E 2	47 to 54	48.25	53.75
	E 3	54 to 61	55.25	60.75
	E 4	61 to 68	62.25	67.75
III	E 5	174 to 181	175.25	180.75
	E 6	181 to 188	182.25	187.75
	E 7	188 to 195	189.25	194.75
	E 8	195 to 202	196.25	201.75
	E 9	202 to 209	203.25	208.75
	E 10	209 to 216	210.25	215.75
	E 11	216 to 223	217.25	222.75
	E 12	223 to 230	224.25	229.75

BAND	CHANNEL	CHANNEL LIMITS (MHZ)	VISION CARRIER	SOUND CARRIER
Standard B (7 Mhz), Europe Special cable TV channels (CATV)				
IF	-	33.15 to 40.15	38.9	33.4
	S 2	113 to 123	digital sound	
	S 3	113 to 123	broadcasting	
	S 4	125 to 132	126.25	131.75
<III	S 5	132 to 139	133.25	138.75
Su	S 6	139 to 146	140.25	145.75
lower	S 7	146 to 153	147.25	152.75
ATV	S 8	153 to 160	154.25	159.75
bands	S 9	160 to 167	161.25	166.75
	S 10	167 to 174	168.25	173.75
	S 11	230 to 237	231.25	236.75
	S 12	237 to 244	238.25	243.75
	S 13	244 to 251	245.25	250.75
	S 14	251 to 258	252.25	257.75
>III	S 15	258 to 265	259.25	264.75
So	S 16	265 to 272	266.25	271.75
upper	S 17	272 to 279	273.25	278.75
ATV	S 18	279 to 286	280.25	285.25
bands	S 19	286 to 293	287.25	292.75
	S 20	293 to 300	294.25	299.75
Standard B (7 Mhz), Italy				
IF	-	33.15 to 40.15	38.9	33.4
I	A	52.5 to 59.5	53.75	59.25
	B	61 to 68	62.25	67.75
(II)	C	81 to 88	82.25	87.75
	D	174 to 181	175.25	180.75
	E	182.5 to 189.5	183.75	189.25
	F	191 to 198	192.25	197.75
(III)	G	200 to 207	201.25	206.75
	H	209 to 216	210.25	215.75
	H1	216 to 223	217.25	222.75
	H2	223 to 230	224.25	229.75

BAND	CHANNEL	CHANNEL LIMITS (MHZ)	VISION CARRIER	SOUND CARRIER
Standard B (7 Mhz), Marocco				
IF	-	33.15 to 40.15	38.9	33.4
	M 4	162 to 169	163.25	168.75
	M 5	170 to 177	171.25	176.75
	M 6	178 to 185	179.25	184.75
III	M 7	186 to 193	187.25	192.75
	M 8	194 to 201	195.25	200.75
	M 9	202 to 209	203.25	208.75
	M 10	210 to 217	211.25	216.75
Standard B (7 Mhz), New Zealand				
IF	-	33.15 to 40.15	38.9	33.4
	1	44 to 51	45.25	50.75
I	2	54 to 61	55.25	60.75
	3	61 to 68	62.25	67.75
	4	174 to 181	175.25	180.75
	5	181 to 188	182.25	187.75
	6	188 to 195	189.25	194.75
III	7	195 to 202	196.25	201.75
	8	202 to 209	203.25	208.75
	9	209 to 216	210.25	215.75
	10	216 to 223	217.25	222.75
Standard D (8 Mhz), China (Peoples Rep.)				
IF	-	31.25 to 39.25	38.0	31.5
	1	48.5 to 56.5	49.75	56.25
	2	56.5 to 64.5	57.75	64.25
I	3	64.5 to 72.5	65.75	72.25
	4	76.0 to 84.0	77.25	83.75
	5	84.0 to 92.0	85.25	91.75
	6	167 to 175	168.25	174.75
	7	175 to 183	176.25	182.75
	8	183 to 191	184.25	190.75
III	9	191 to 199	192.25	198.75
	10	199 to 207	200.25	206.75
	11	207 to 215	208.25	214.75

BAND	CHANNEL	CHANNEL LIMITS (MHZ)	VISION CARRIER	SOUND CARRIER
Standard D (8 Mhz), China (Peoples Rep.)				
	12	215 to 223	216.25	222.75
Standard D (8 Mhz), OIRT				
IF*	-	32.15 to 40.15	38.9	32.4
**UdSSR: 31.25 to 39.25/38.0/31.5 Mhz*				
	R I	48.5 to 56.5	49.75	56.25
I	R II	58 to 66	59.25	65.75
	R III	76 to 84	77.25	83.75
(II)	R IV	84 to 92	85.25	91.75
	R V	92 to 100	93.25	99.75
	R VI	174 to 182	175.25	181.75
	R VII	182 to 190	183.25	189.75
	R VIII	190 to 198	191.25	197.75
III	R IX	198 to 206	199.25	205.75
	R X	206 to 214	207.25	213.75
	R XI	214 to 222	215.25	221.75
	R XII	222 to 230	223.25	229.75
Standard I (8 Mhz), Ireland				
IF	-	32.15 to 40.15	38.9*	32.9*
**Gr.-Brit. Also 39.5 and 33.5 Mhz resp.*				
	I A	44.5 to 52.5	45.75	51.75
I	I B	52.5 to 60.5	53.75	59.75
	I C	60.5 to 68.5	61.75	67.75
	I D	174 to 182	175.25	181.25
	I E	182 to 190	183.25	189.25
III	I F	190 to 198	191.25	197.75
	I G	198 to 206	199.25	205.25
	I H	206 to 214	207.25	213.25
	I J	214 to 222	215.25	221.25

BAND	CHANNEL	CHANNEL LIMITS (MHZ)	VISION CARRIER	SOUND CARRIER
Standard I (8 Mhz), South Africa				
IF	-	32.15 to 40.15	38.9	32.9
III	4	174 to 182	175.25	181.25
	5	182 to 190	183.25	189.25
	6	190 to 198	191.25	197.25
	7	198 to 206	199.25	205.25
	8	206 to 214	207.25	213.25
	9	214 to 222	215.25	221.25
	10	222 to 230	223.25	229.25
	11	230 to 238	231.25	237.25
	(12)	238 to 246	not defined	
	13	246 to 254	247.43	253.43
Standard K1 (8 Mhz) *French Overseas Post and Telecommunication Agency*				
IF	-	31.45 to 39.45	32.7	39.2*
**Also 38.9 or 32.7 Mhz*				
III	4	174 to 182	175.25	181.75
	5	182 to 190	183.25	189.75
	6	190 to 198	191.25	197.75
	7	198 to 206	199.25	205.75
	8	206 to 214	207.25	213.75
	9	214 to 222	215.25	221.75
Standard L (8 Mhz), France				
IF	-	31.45 to 39.45	32.7	39.2*
**Also 38.9 or 32.7 Mhz*				
I	A	41 to 49	47.75	41.25
	B	49 to 57	55.75	49.25
	C	57 to 65	63.75	57.25
	C 1	53.75 to 61.75	60.50	54.00

BAND	CHANNEL	CHANNEL LIMITS (MHZ)	VISION CARRIER	SOUND CARRIER
Standard L (8 Mhz), France				
III	1	174.75 to 182.75	176.0	182.50
	2	182.75 to 190.75	184.0	190.50
	3	190.75 to 198.75	192.0	198.50
	4	198.75 to 206.75	200.0	206.50
	5	206.75 to 214.75	208.0	214.50
	6	214.75 to 222.75	216.0	222.50
Standard M (6 Mhz), Japan				
IF	-	41.0 to 47.0	38.9	41.25
(II)	J 1	90 to 96	91.25	95.75
	J 2	96 to 102	97.25	101.75
	J 3	102 to 108	103.25	107.75
III	J 4	170 to 176	171.25	175.75
	J 5	176 to 182	177.25	181.75
	J 6	182 to 188	183.25	187.75
	J 7	188 to 194	189.25	193.75
		Channel spacing 4 Mhz		
III	J 8	192 to 198	193.25	197.75
		Channel spacing 4 Mhz		
	J 9	198 to 204	199.25	203.75
	J 10	204 to 210	205.25	209.75
	J 11	210 to 216	211.25	215.75
	J 12	216 to 222	217.25	221.75
Standard M,N (6 Mhz), USA				
IF	-	41.0 to 47.0	45.75	41.25
I	A 02	54 to 60	55.25	59.75
	A 03	60 to 66	61.25	65.75
	A 04	66 to 72	67.25	71.75
	A 05	76 to 82	77.25	81.75
	A 06	82 to 88	83.25	87.75

BAND	CHANNEL	CHANNEL LIMITS (MHZ)	VISION CARRIER	SOUND CARRIER
Standard M,N (6 Mhz), USA				
III	A 07	174 to 180	175.25	179.75
	A 08	180 to 186	181.25	185.75
	A 09	186 to 192	187.25	191.75
	A 10	192 to 198	193.25	197.75
	A 11	198 to 204	199.25	203.75
	A 12	204 to 210	205.25	209.75
	A 13	210 to 216	211.25	215.75

UHF Channel definitions

BAND	CHANNEL		CHANNEL LIMITS MHZ	VISION CARRIER	SOUND CARRIER MHZ		
	EU	Chi			G,H	I	K,L
Standards G,H,I,K,L (CCIR standards;8 Mhz)							
IF	-	-	same of VHF for corrisponding country				
	21	13	470 to 478	471.25	476.25	477.25	477.75
	22	14	478 to 486	479.25	484.75	485.25	485.75
	23	15	486 to 494	487.25	492.75	493.25	493.75
	24	16	494 to 502	495.25	500.75	501.25	501.75
	25	17	502 to 510	503.25	508.75	509.25	509.75
	26	18	510 to 518	511.25	516.75	517.25	517.75
	27	19	518 to 526	519.25	524.75	525.25	525.75
	28	20	526 to 534	527.25	532.75	533.25	533.75
IV	29	21	534 to 542	535.25	540.75	541.25	541.75
	30	22	542 to 550	543.25	548.75	549.25	549.75
	31	23	550 to 558	551.25	556.75	557.25	557.75
	32	24	558 to 566	559.25	564.75	565.25	565.75
	33	|	566 to 574	567.25	572.75	573.25	573.75
	34	not	574 to 582	575.25	580.75	581.25	581.75
	35	defi	582 to 590	583.25	588.75	589.25	589.75
	36	ned	590 to 598	591.25	596.75	597.25	597.75
	37	|	598 to 606	599.25	604.75	605.25	605.75
	38	25	606 to 614	607.25	612.75	613.25	613.75
	39	26	614 to 622	615.25	620.75	621.25	621.75
	40	27	622 to 630	623.25	628.75	629.25	629.75
	41	28	630 to 638	631.25	636.75	637.25	637.75
	42	29	638 to 646	639.25	644.75	645.25	645.75
	43	30	646 to 654	647.25	652.75	653.25	653.75
V	44	31	654 to 662	655.25	660.75	661.25	661.75
	45	32	662 to 670	663.25	668.75	669.25	669.75
	46	33	670 to 678	671.25	676.75	677.25	677.75
	47	34	678 to 686	679.25	684.75	685.25	685.75
	48	35	686 to 694	687.25	692.75	693.25	693.75
	49	36	694 to 702	695.25	700.75	701.25	701.75

BAND	CHANNEL		CHANNEL LIMITS MHZ	VISION CARRIER	SOUND CARRIER MHZ		
	EU	Chi			G,H	I	K,L
Standards G,H,I,K,L (CCIR standards;8 Mhz)							
	50	37	702 to 710	703.25	708.75	709.25	709.75
	51	38	710 to 718	711.25	716.75	717.25	717.75
	52	39	718 to 726	719.25	724.75	725.25	725.75
	53	40	726 to 734	727.25	732.75	733.25	733.75
	54	41	734 to 742	735.25	740.75	741.25	741.75
	55	42	742 to 750	743.25	748.75	749.25	749.75
	56	43	750 to 758	751.25	756.75	757.25	757.75
	57	44	758 to 766	759.25	764.75	765.25	765.75
	58	45	766 to 774	767.25	772.75	773.25	773.75
	59	46	774 to 782	775.25	780.75	781.25	781.75
	60	47	782 to 790	783.25	788.75	789.25	789.75
	61	48	790 to 798	791.25	796.75	797.25	797.75
V	62	49	798 to 806	799.25	804.75	805.25	805.25
	63	50	806 to 814	807.25	812.75	813.25	813.25
	64	51	814 to 822	815.25	820.75	821.25	821.25
	65	52	822 to 830	823.25	828.75	829.25	829.25
	66	53	830 to 838	831.25	836.75	837.25	837.25
	67	54	838 to 846	839.25	844.75	845.25	845.25
	68	55	846 to 854	847.25	852.75	853.25	853.75
	69	56	854 to 862	855.25	860.75	861.25	861.75
	|	57	862 to 870	863.25			869.75
	not	58	870 to 878	871.25			877.75
	defi	59	878 to 886	879.25			885.75
	ned	60	886 to 894	887.25			893.75
	|	61	894 to 902	895.25			901.75
	|	62	902 to 910	903.25			909.75

EU = EUROPE
Chi = CHINA

BAND	CHANNEL		CHANNEL LIMITS MHZ	VISION CARRIER	SOUND CARRIER
	USA Can	Jap			
Standards M,N (6 Mhz), USA;Standards M (6 Mhz) Japan					
IF	-	-	same as VHF for corresponding country		
	14	13	470 to 476	471.25	475.75
	15	14	476 to 482	477.25	481.75
IV			other channels with 6 Mhz spacing		
	41	40	632 to 638	633.25	637.75
	42	41	638 to 644	639.25	643.75
	43	42	644 to 650	645.25	649.75
	44	43	650 to 656	651.25	655.75
	45	44	656 to 662	657.25	661.75
	46	45	662 to 668	663.25	667.75
	47	46	668 to 674	669.25	673.75
	48	47	674 to 680	675.25	679.75
	49	48	680 to 686	681.25	685.75
	50	49	686 to 692	687.25	691.75
	51	50	692 to 698	693.25	697.75
	52	51	698 to 704	699.25	703.75
	53	52	704 to 710	705.25	709.75
	54	53	710 to 716	711.25	715.75
	55	54	716 to 722	717.25	721.75
V	56	55	722 to 728	723.25	727.75
	57	56	728 to 734	729.25	733.75
	58	57	734 to 740	735.25	739.75
	59	58	740 to 746	741.25	745.75
	60	59	746 to 752	747.25	751.75
	61	60	752 to 758	753.25	757.75
	62	61	758 to 764	759.25	763.75
	63	62	764 to 770	765.25	769.75
	64	|	770 to 776	771.25	775.75
	65	not	776 to 782	777.25	781.75
	66	defi	782 to 790	783.25	787.75
	67	ned	788 to 794	789.25	793.75

BAND	CHANNEL		CHANNEL LIMITS MHZ	VISION CARRIER	SOUND CARRIER
	USA Can	Jap			
Standards M,N (6 Mhz), USA;Standards M (6 Mhz) Japan					
	68	|	794 to 800	795.25	799.75
	69	|	800 to 806	801.25	805.75
	70	|	806 to 812	807.25	811.75
	71	|	812 to 818	813.25	817.75
	72	|	818 to 824	819.25	823.75
	73	|	824 to 830	825.25	829.75
	74	not	824 to 830	831.25	835.75
V	75	defi	830 to 836	837.25	841.75
	76	ned	836 to 842	843.25	847.75
	77	|	842 to 848	849.25	853.75
	78	|	848 to 854	855.25	859.75
	79	|	854 to 860	861.25	865.75
	80	|	860 to 866	867.25	871.75
	81	|	866 to 872	873.25	877.75
	82	|	878 to 884	879.25	883.75
	83	|	884 to 890	885.25	889.75
Standard B (7 Mhz), Australia					
IF	-		33.15 to 40.15	38.9	33.4
	28		526 to 533	527.25	532.75
	29		533 to 540	534.25	539.75
	30		540 to 547	541.25	546.75
IV	31		547 to 554	548.25	553.75
	32		554 to 561	555.25	560.75
	33		561 to 568	562.25	567.75
	34		568 to 575	569.25	574.75
	35		575 to 582	576.25	581.75
	36		582 to 589	583.25	588.75
	37		589 to 596	590.25	595.75
	38		596 to 603	597.25	602.75
	39		603 to 610	604.25	609.75
	40		610 to 617	611.25	616.75

BAND	CHANNEL	CHANNEL LIMITS MHZ	VISION CARRIER	SOUND CARRIER
Standard B (7 Mhz), Australia				
	41	617 to 624	618.25	623.75
	42	624 to 631	625.25	630.75
	43	631 to 638	632.25	637.75
	44	638 to 645	639.25	644.75
	45	645 to 652	646.25	651.75
	46	652 to 659	653.25	658.75
	47	659 to 666	660.25	665.75
	48	666 to 673	667.25	672.75
	49	673 to 680	674.25	679.75
	50	680 to 687	681.25	686.75
	51	687 to 694	688.25	693.75
	52	694 to 701	695.25	700.75
	53	701 to 708	702.25	707.75
	54	708 to 715	709.25	714.75
	55	715 to 722	716.25	721.75
	56	722 to 729	723.25	728.75
	57	729 to 736	730.25	735.75
	58	736 to 743	737.25	742.75
	59	743 to 750	744.25	749.75
	60	750 to 757	751.25	756.75
	61	757 to 764	758.25	763.75
	62	764 to 801	765.25	770.75
	63	771 to 779	772.25	777.75
	64	778 to 786	779.25	784.75
	65	785 to 793	786.25	791.75
	66	792 to 799	793.25	798.75
	67	799 to 806	800.25	805.75
	68	806 to 813	807.25	812.75
	69	813 to 820	814.25	819.75
USA = United States of America *Can = Canada* *Jap = Japan*				

Basic standards for TV transmission

STANDARD		B/G CCIR	D/K OIRT	H BELGIUM
Frequency		VHF/UHF	VHF/UHF	UHF
Number of lines for frame		625	625	625
Field frequency	Hz	50	50	50
Line frequency	Hz	15625	15625	15625
Duration of line sync pulse	µs	4.7	4.7	4.7
Duration of line blanking pulse	µs	12	12	12
Front porch	µs	1.5	1.5	1.5
Field blanking interval	Lines	25	25	25
Standard color system		PAL/SECAM	SECAM	PAL/SECAM
Chrominance subcarrier freq.	Hz			
PAL	Hz	4433618.75±5		4433618.75±5
SECAM/NTSC	Hz kHz	f_{OR}=4406250±2000 f_{OB}=4250000±2000 (f_O=4286±20) f_{OR}=282f_H f_{OB}=272f_H	f_{OR}=4406250±2000 f_{OB}=4250000±2000 (f_O=4286±20) f_{OR}=282f_H f_{OB}=272f_H	f_{OR}=4406250±2000 f_{OB}=4250000±2000 (f_O=4286±20) f_{OR}=282f_H f_{OB}=272f_H
Video bandwidth	Mhz	5	6	5
RF channel width	Mhz	7(B) / 8(G)	8	8
Vision-sound carrier spacing	Mhz	+5.5 +5.74[6]	+6.5	+5.5
Width of vestigial sideband	Mhz	0.75	0.75	1.25
Spacing of vision carrier from nearest edge of channel	Mhz	+1.25	+1.25	+1.25
RF sync level	%	100	100	100
RF blanking level	%	733	75	75
RF white level (residual carrier)	%	10	12.5	10
Type of vision modulation		C3F neg.	C3F neg.	C3F neg.
Type of sound modulation		F3E F3EH[6]	F3E	F3E
Frequency deviation		±50	±50	±50
Preemphasis	µs	50	50	50
Vision/Sound power ratio		10:1 to 20:1[4] 20:1:0.2[6]	10:1 to5:1	5:1 to10:1

* = group of territories represented by the French Overseas Post and Telecommunication Agency
2 = for colour transmission according to NTSC or SECAM
3 = 73% instead of nominal 75% applies for TV transmitters of high quality also in the sync range (burst, chrominance signal)
4 = 20:1 in the Federal Republic of Germany as of April 1976 for all trasmission of the three programs
5 = 6.7:1 and 2.9:1 in Japan
6 = for dual-sound or stereo sound in the Federal Republic of Germany

I UK	K1 OR K FOPTA*	L FRANCE	M FCC	N SOUTH AMERICA
VHF/UHF	VHF/UHF	VHF/UHF	VHF/UHF	VHF/UHF
625	625	625	525	625
50	50	50	60	50
15625	15625	15625	15750	15625
4.7	4.7	4.7	5 (4.7)[2]	5
12	12	12	10.8 (11)[2]	10.9
1.5	1.5	1.5	1.9 (1.75)[2]	1.9
25	25	25	19 to 21	19 to 25
PAL	SECAM	SECAM	PAL/NTSC	PAL
4433618.75±5			3575611.49±10	3582056.25±5
	f_{OR}=4406250±2000 f_{OB}=4250000±2000 (f_O=4286±20) f_{OR}=282f_H f_{OB}=272f_H	f_{OR}=4406250±2000 f_{OB}=4250000±2000 (f_O=4286±20) f_{OR}=282f_H f_{OB}=272f_H	3579545±10	
5.5	6	6	4.2	4.2
8	8	8	6	6
+6	+6.5	±6.5	+4.5	+4.5
1.25	1.25	1.25	0.75	0.75
+1.25	+1.25	+1.25	+1.25	+1.25
100	100	<6	100	100
76	75	30	75	75
20	10	100 (110)[2]	10	10
C3F neg.	C3F neg.	C3F pos.	C3F neg.	C3F neg.
F3E	F3E	A3E	F3E	F3E
±50	±50	-	±25	±25
50	50	-	75	75
5:1	10:1	10:1	10:1 to 5:1[5]	10:1 to 5:1

Minimum field strength for which protection may be sought in planning a television service

(Ref.: CCIR Rec. 417-3)

✧ When planning a television service in bands I, III, IV, V, the median field strength for which protection against interference is planned should never be lower than:

BAND	**I**	**III**	**IV**	**V**
*dB (*µV/m)	+48	+55	+65([1])	+70([1])

([1]) The values shown for band IV and V should be increased by 2 dB for the 625-line (OIRT) system

These values refers to the field strength at a height of 10m above ground level;

✧ The percentage of time for which the protection may be sought should lie between 90% and 99%

Note1. In arriving at the figure shown above, it has been assumed that, in the absence of interference from other television transmissions and man-made noise, the minimum field strength at the receiving antenna that will give a satisfactory grade of picture, taking into consideration receiver noise, cosmic noise, antenna gain and feeder loss, are: +47dB(µV/m) in Band I, +53 dB(µV/m) in Band III, +62 dB(µV/m) in Band IV and +67 dB(µV/m) in Band V

Note 2. Further information concerning the planning of television service for sparsely populated regions is contained in CCIR report 409.

Note 3. In a practical plan, because of interference from other television transmissions, the field strengths that can be protected will generally be higher than those quoted above, and the exact values to be used in the boundary areas between any two countries should be agreed between the administrations concerned.

Boundaries of the television service area in rural districts having a low population density

(Ref.: CCIR Rep. 409 - 4)

Where television services are to be provided for a sparsely populated region, in which better receivers and antenna installation are likely to be employed than those considered in CCIR Rec. 417, administrations may find it desirable to establish the appropriate median field strength for which protection against interference is planned as low as shown below.

BAND	**I**	**III**	**IV**	**V**
dB(μV/m)	+46	+49	+58	+64

These values refer to the field strength at a height of 10 m above ground level.

In the absence of interference other than noise, field strength of the order of 40 dB(μV/m) in Band I, 43 dB(μV/m) in Band III, 52 dB(μV/m) in Band IV, 58 dB(μV/m) in Band V can give satisfactory pictures; however, it is generally observed that the public begin to lose interest in installing television reception equipment when the field strength falls much below these levels.

The values given in this Report have been obtained from field-strength investigations at the edge of the coverage area and picture quality assessments for Bands I and III in rural districts of Australia [CCIR, 1963-66], India [CCIR, 1974-78] and Italy, for Bands IV, and V at both rural and urban location in Italy and the United Kingdom [CCIR, 1982-86]. It may be noted that in Bands IV and V where man-made noise is not generally a problem, the field strength values quoted for rural areas, may also be applied in urban areas.

CO-Channel interference

(Ref.: CCIR Rec. 655)

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 the system G lies within the vision channel of system K). For all protection ratio figures in this section, the following correction 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 shuold be reduced by 2 dB.

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

- Carriers separated by less then 1000 Hz, non-controlled systems having the same or different line standard:
  - Protection ratio: 45 dB, tropospheric interference
- Carriers separated by parts of the line frequency, systems having the same line-standard, non-precision offset:

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

- 625-line system, 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.

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 (dB)	45	44	40	34	30	28	27	28	30	34	40	44	45
	Continuous interference (dB)	52	51	48	44	40	36	33	36	40	44	48	51	52
	Limit of perceptibility (dB)	61	60	57	54	50	45	42	45	50	54	57	60	61
Precision offset Transmitter stability ± 1 Hz	Tropospheric interference (dB)	32	34	30	26	22	22	24	22	22	26	30	34	38
	Continuous interference (dB)	36	38	34	30	27	27	30	27	27	30	34	38	42
	Limit of perceptibility (dB)	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 ±36/12).

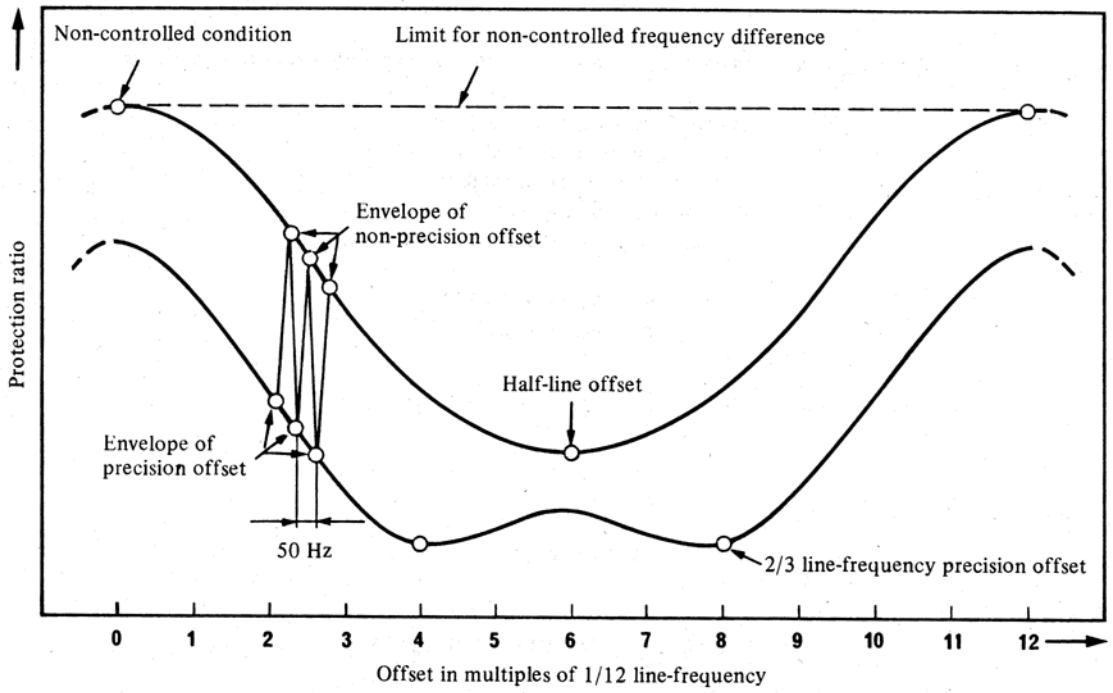
Frequency offset conditions

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 within ±500Hz.

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. In the following figure is shown the main characteristic of offset operation which 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 the 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 ratio 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.



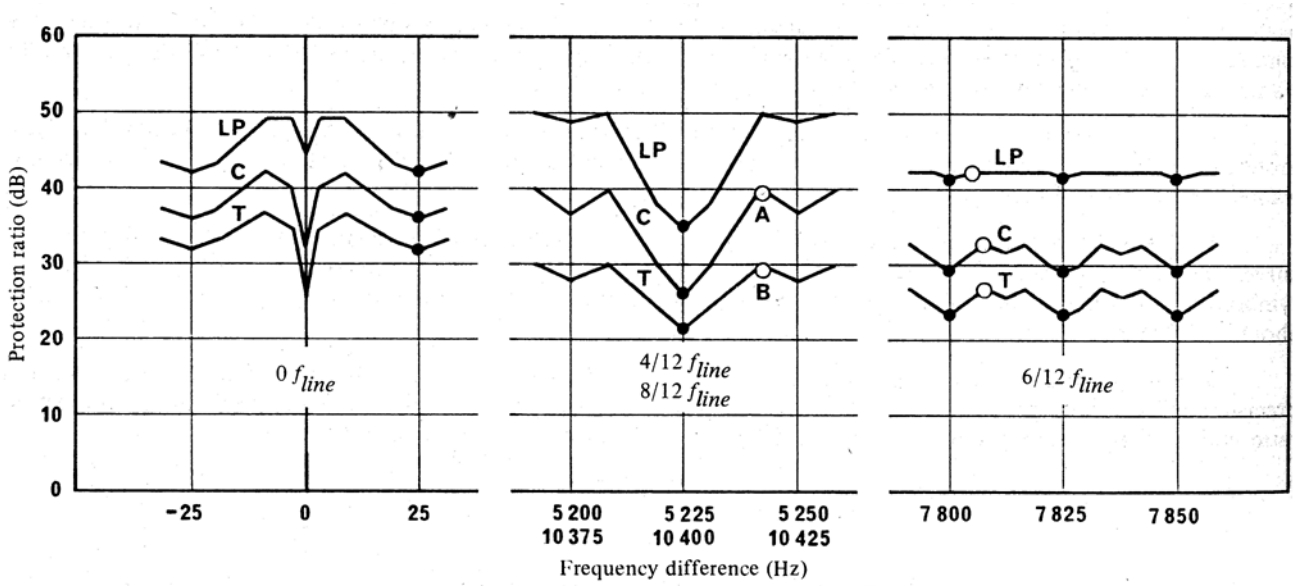
Schematic protection ratio curves with different offset positions

CO-Channel protection ratio curves in the vicinity of 0/12, 4/12 and 6/12 line frequency (625-line system)

The following figure gives examples of protection ratio curves for the three most important offset position (0/12,4/12 and 6/12 f_{line}). The curves in each graph relate to the 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.



Precise structure of the protection ratio curves for different offset positions

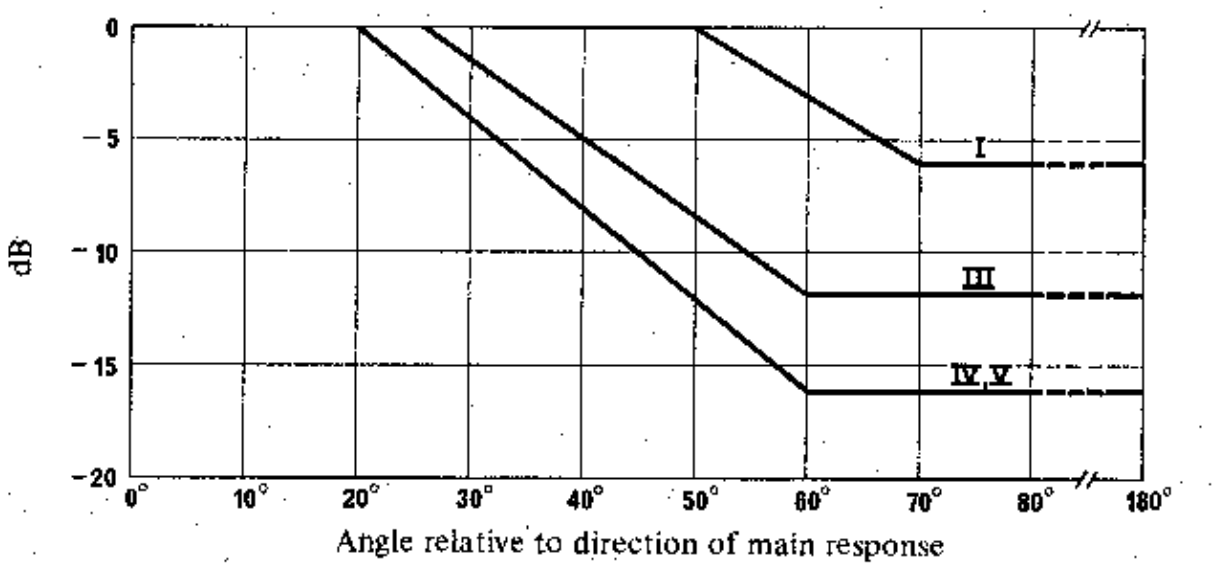
Curves T: tropospheric interference
C: continuous interference
LP: limit of perceptibility
A: continuous interference reference point
B: tropospheric interference reference point

○ Non-precision offset
● Precision offset

Directivity of antennas in the reception of television broadcasting

(Ref.: CCIR Rec. 419-1)

Characteristics of directivity of the receiving antennas that can be used for planning terrestrial television services in broadcasting Bands I, III, IV and V .



Discrimination obtained by the use of directional receiving antennas in broadcasting

(The number of the broadcasting band is shown on the curve)

- ✧ It is considered that the discrimination shown will be available at the majority of antenna location in built-up areas. At clear sites in open country, slightly higher values will be obtained.

- ✧ The curves shown above are valid for signals of vertical or horizontal polarization, when both the wanted and the unwanted signals have the same polarization.

Microwave radiation exposure - principal safety standards

Frequency range:

- ✧ USAS C95.1 - 10 Mhz - 100 Ghz
- ✧ Military - all microwave frequencies - range not specified
- ✧ USSR - 300 Mhz to 30 Ghz
- ✧ Czech - 300 Mhz to 300 Ghz

Definition of Power Density:

Power Densities referred to in standards is that average density measured in accessible regions (USASI, or military) or at actual exposure sites (USSR and Czech) in the absence of subject.

Averaging time:

USAS C95.1 - 0.1 hour or 6 minutes

AF and ARMY - 0.01 hour or 36 seconds

Navy - 3 seconds

USSR - not specified

Czech - not specified, but the standard implies that an average density is calculated from an integrated dose. For example, for occupational situations the maximum permissible exposure is given by:

$$\int_0^8 PdT \quad < \quad 200 \text{ microwatts} / \text{cm}^2 \text{ - hours}$$

averaged over 8 hours where P is power density and T is time in hour. The total exposure dose over five consecutive working days is summed and divided by 5 to obtain an average exposure dose for 8 hours.

Dependence on Area of Exposure:

No distinctions are generally made between partial and whole body exposure.

Modification for Pulse or Other Modulation:

None except for reduction of exposure level by a factor of 2.5 in Czech standards.

Restriction on Peak Power:

None.

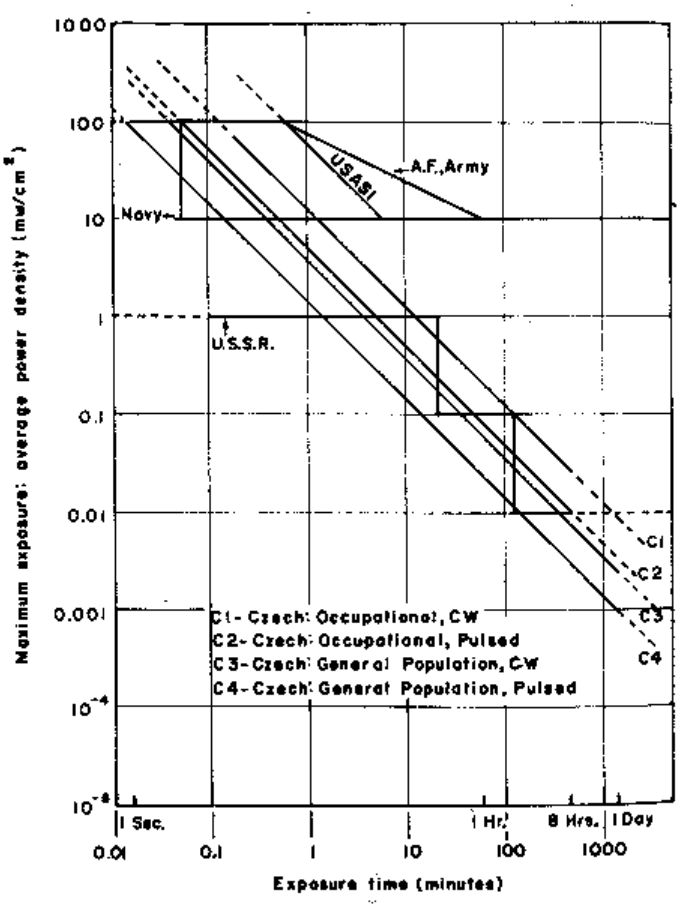
Allowance for Environment:

None except for proposal by Mumford to reduce the radiation exposure guide from 10 mw/cm^2 according to the formula Po(mw/cm^2) = 10 - (THI - 70) for values of the temperature-humidity index (THI) in the range of 70 to 79 with Po = 1 mw/cm^2 for THI above 79.

Instrumentation:

Generally not well specified but far-field type probes such as small horns or open waveguides are specified with effective apertures $A_e = \lambda^2 / 4\pi G$ where G is the power gain. Response times are not well specified but are implied to be much greater than pulse durations and much smaller than duration of exposure, generally of the order of seconds. Some use of true dosimetry, integrated absorbed energy is made in USSR and Czechoslovakia.

Under USSR standard exposure near 1 mW/cm^2 is permitted only with use of protective goggles for the eyes.



Coaxial cables

CABLE TYPE	IMPEDANCE Ω	DIELECTRIC	VELOCITY FACTOR	FREQUENCY [MHZ] MAXIMUM POWER [KW] / ATTENUATION [DB/100 M]			
				50		100	
				Kw	dB	Kw	dB
RG 58	50	Compact Polythene	0.67	0.42	10.8	0.3	16.1
RG 59	75	Compact Polythene	0.66	0.75	8.0	0.50	11.2
RG 213	50	Compact Polythene	0.66	2.7	4.27	1.7	6.23
RG 8	52	Compact Polythene	0.66	2.7	4.27	1.7	6.23
RG 11	75	Compact Polythene	0.66	1.7	4.80	1.03	7.0
1/4 Inch	50	Expanded Polythene (FOAM)	0.84	0.985	4.17	0.690	5.94
1/2 Inch	50	Expanded Polythene (FOAM)	0.81	2.91	2.40	2.03	3.44
7/8 Inch	50	Expanded Polythene (FOAM)	0.89	7.74	0.843	5.38	1.21
1+5/8 Inch	50	Expanded Polythene (FOAM)	0.88	19.3	0.512	13.4	0.738
1/2 Inch	50	Air Dielectric	0.914	2.97	1.90	2.10	2.72
5/8 Inch	50	Air Dielectric	0.92	6.00	1.12	4.21	1.60
7/8 Inch	50	Air Dielectric	0.90	9.20	0.853	6.40	1.21
1+5/8 Inch	50	Air Dielectric	0.921	20.7	0.476	14.4	0.679
3 Inch	50	Air Dielectric	0.933	54.0	0.322	29.1	0.448
4 Inch	50	Air Dielectric	0.92	82.0	0.256	56.0	0.371
5 Inch	50	Air Dielectric	0.931	107	0.177	73.0	0.259

FREQUENCY [MHZ] Maximum power [Kw] / Attenuation [dB/100 m]													
200		500		800		1000		2000		3000		8000	
Kw	dB	Kw	dB	Kw	dB	Kw	dB	Kw	dB	Kw	dB	Kw	dB
0.2	24.3	0.18	39.6	0.14	39.8	0.125	55.0	0.08	75.0	0.62	111.5	-	-
0.35	16.1	0.23	27.0	0.17	37.0	0.15	43.0	0.09	68.0	0.07	85.0	-	-
1.1	8.86	0.65	17.0	0.48	23.0	0.40	26.0	0.30	43.0	0.19	57.0	-	-
1.1	8.86	0.65	17.0	0.48	23.0	0.40	26.0	0.30	43.0	0.19	57.0	-	-
0.81	10.03	0.48	17.0	0.36	25.0	0.30	29.0	0.19	46.0	0.15	60.0	-	-
0.482	8.46	0.298	13.7	0.231	17.5	0.205	19.7	0.14	28.6	0.111	35.8	0.062	62.7
1.42	4.92	0.867	8.06	0.669	10.4	0.59	11.7	0.4	17.4	0.318	22.1	0.166	42.0
3.72	1.76	2.25	2.90	1.73	3.78	1.52	4.30	1.01	6.46	0.785	8.31	-	-
9.22	1.08	5.53	1.79	4.21	2.36	3.69	2.69	2.42	4.10	-	-	-	-
1.48	3.90	0.924	6.13	0.720	7.77	0.640	8.69	0.44	12.6	0.338	16.2	0.175	32.2
2.94	2.29	1.82	3.71	1.41	4.76	1.25	5.37	0.858	7.86	0.682	9.89	-	-
4.40	1.77	2.69	2.85	2.09	3.68	1.85	4.17	1.30	6.07	1.0	7.90	-	-
10.0	0.951	6.21	1.57	4.82	2.03	4.30	2.30	2.90	3.44	-	-	-	-
25.0	0.682	14.6	1.2	9.24	1.60	9.30	1.84	-	-	-	-	-	-
38.7	0.545	22.6	0.943	17.1	1.24	15.0	1.41	-	-	-	-	-	-
51.0	0.377	30.7	0.626	23.0	0.820	-	-	-	-	-	-	-	-

Wave guides

GUIDE TYPE	TE_{11} MODE CUTOFF [GHZ]	MAXIMUM FREQ. RANGE [GHZ]	ATTENUATION [DB/100 M]	MAX POWER [W]	VELOCITY FACTOR
EW 127 A	7.67	10.0 - 13.25	11.83	1.24	0.78
EW 132	9.22	11.0 - 15.35	15.84	0.85	0.78

TV analogue microwave links

SYSTEM STANDARD

IF FREQUENCY:	70 Mhz
MODULATION TYPE:	F.M.
NOMINAL FREQUENCY DEVIATION:	8 Mhz p.p.
	(REC. 276-2)
PREEMPHASIS / DEEMPHASIS:	525 Lines Standard or
	625 Lines Standard
	(REC. 405 - 1)
STANDARD AUDIO CARRIERS	
FREQUENCY:	7.500 Mhz (1°)
8.590 Mhz	
	7.020 Mhz
8.65Mhz	
(REP. 289-4)	
AUDIO SUBCARRIER MODULATION	
TYPE:	F.M.
STANDARD NOMINAL MAXIMUM AUDIO	
SUBCARRIER DEVIATION	
(with audio signal):	± *100 Khz p.*
STANDARD AUDIO SUBCARRIER	
PREEMPHASIS:	*50*µ*S*

VSWR vs. Return loss (dB)

VSWR	RETURN LOSS (DB)
1.00	∞
1.05	32.3
1.10	26.4
1.15	23.1
1.20	20.8
1.22	20.1
1.25	19.1
1.30	17.7
1.40	15.6
1.50	14.0
1.70	11.7
1.92	10.0
2.00	9.5
3.00	6.0
6.00	2.9
10.00	1.7

Half wave dipole vs. isotropic dipole

Half wave dipole gain (with reference to isotropic radiatior) ≅ 2.2 dB

Units:

Antenna gain (with reference to isotropic radiator): dBi

Antenna gain (with reference to half wave dipole): dBd

Generally: dBd = dBi - 2.2

Relationship between dBm, W, dBμV, V

dBm	POWER	DBμV	VOLTAGE
-100	0.1 pW	7	2.2 μV
-90	1 pW	17	7 μV
-80	10 pW	27	22 μV
-70	100 pW	37	70 μV
-60	1 nW	47	220 μV
-50	10 nW	57	700 μV
-47	20 nW	60	1 mV
-40	100 nW	67	2.2 mV
-30	1 μV	77	7 mV
-20	10 μV	87	22 mV
-10	100 μV	97	70 mV
0	1 mW	107	220 mV
10	10 mW	117	700 mV
20	100 mW	127	2.2 V
30	1 W	137	7 V
40	10 W	147	22 V
50	100 W	157	70 V
60	1 kW	167	220 V
70	10 kW	177	700 V
80	100 kW	187	2.2 kV
90	1 MW	197	7 kV

These values refers to 50 Ω Impedance. (For 75 Ω voltage values must be increased by 20%).

Cable size vs. maximum current

Maximum current carrying capacity for copper cable insulated with proper rubber and textile.This capacities for cable placed in free air with an ambient temperature of 35 °.

These values are for cables in free air (not bunded) at any ambient.

NOMINAL CROSS SECTION AREA	PLACED IN FREE AIR				
	1-pole cable	2-pole cable	3-pole cable	N°of conductors	Diameter (mm)
mm^2	Amperes	Amperes	Amperes		
0.5	3	3	3	1	0.8
0.75	5	5	5	1	1
1	7	7	7	1	1.15
1.5	10	10	10	1	1.4
2.5	16	16	16	1	1.8
4	22	22	22	1	2.25
6	31	30	30	1	2.8
10	47	45	40	7	1.35
16	66	61	51	7	1.7
25	88	83	68	7	2.15
35	108	95	84	7	2.5
50	135	128	105	19	1.8
75	176	167	135	19	2.25
100	213	202	165	19	2.6
120	240	227	186	37	2
150	280	263	217	37	2.25
180	325	300	245	37	2.5
200	375	320	260	37	2.6

Conversion factors

LENGTH:

UNITS	METER	MILS	INCH	FEET	YARD	TERR. MILE (1)	NAUT. MILE(2)
METER	1	39370	39.37	3.281	1.094	0.000621	0.00054
MILS	2.540E-5	1	0.001	8.333E-5	2.778E-5	-	-
INCH	0.02540	1000	1	0.083	0.0278	-	-
FEET	0.3048	12000	12	1	0.333	-	-
YARD	0.914	35997	36	3	1	-	-
TERR. MILE(1)	1609	-	-	5279	1760	1	0.868
NAUT. MILE(2)	1853	-	-	6080	2027	1.151	1

(1)Terr. Mile = Terrestrial Mile; (2)Naut. Mile = Nautical Mile;

1 micron = 1E-3 millimetres;

1 angstrom = 1E-7 millimetres

PRESSURE

UNITS	ATM.(1)	MMH_20	MMHG	PA.(2)	BAR	KG/CM^2
ATM.(1)	1	10332	760	101325	1.01327	1.03333
MMH_20	9.68E-5	1	0.07355	9.81	9.81E-5	1.0003E-4
MMHG	1.316E-3	13.597	1	133.34	1.333E-3	1.359E-3
PA.(2)	9.87E-6	0.102	7.5E-3	1	1.0001E-5	1.02E-5
BAR	0.9869	10196.69	750.04	99998.02	1	1.02
KG/CM^2	0.9677	9998.74	735.486	98059.61	0.980	1

(1)Atm. = Atmosphere; (2)Pa. = Pascal

MASS

UNITS	KILOGRAM	POUND	OUNCE	DYNES
KILOGRAM	1	2.205	35.27	980665
POUND	0.4535	1	16	444746
OUNCE	0.02835	0.0625	1	27804.5
DYNES	1.02E-6	2.248E-6	36E-6	1

TEMPERATURE

UNITS	°C(1)	°F(2)	K(3)	°R(4)
°C(1)	-	(5*°F)/9-17.78	K-273.15	(5*°R/9)-273.17
°F(2)	(9*°C/5)+32	-	(9*°K/5)-459.67	°R-459.67
K(3)	°C+273.15	(5*°F/9)+255.37	-	(5*°R)/9
°R(4)	(9*°C/5)+491.67	°F+459.67	(9 °R)/5	-

(1) °C = Celsius; (2) °F = Fahreneit; K = Kelvin; °R = Rankine

ENERGY

UNITS	BTU	CALORIE,GRAM	JOULE	ERG
BTU	1	252	1054.8	1.055E10
CALORIE,GRAM	3.9685E-3	1	4.1857	41865079.36
JOULE	9.48E-4	0.2389	1	1E7
ERG	9.48E-11	0.2389E-7	1E-7	1

POWER

UNITS	WATT	BTU/HR	HP	KG-CAL/MIN
WATT	1	3.412	1.341E-3	0.01433
BTU/HR	0.2931	1	3.93E-4	4.2E-3
HP	745.712	2544.22	1	10.68
KG-CAL/MIN	69.78	238.1	0.0936	1

Useful formulae

Electrical formulae

Electrical power in KW:

- DC power [KW]: $\frac{volt \times ampere}{1000}$
- AC power (single phase) [KW] $\frac{volt \times ampere}{1000} \times \cos(\varphi)$
- AC power (three-phase) [KW]: $1.73 \times \frac{volt \times ampere}{1000} \times \cos(\varphi)$

where:

Volt: linked voltage

Ampere: single phase current or balanced mean of the 3 cables current

All with balanced load

φ = power factor

General information

Medium radius of earth = 6371.03 Km

Equatorial radius of earth = 6376.8 Km

Polar radius of earth = 6355.41

Resistivity for some common metals:

Silver 0.0164 Ω*mm^2/m

Copper 0.0178 Ω*mm^2/m

Gold 0.0223 Ω*mm^2/m

Brass 0.077 Ω*mm^2/m

RF formulae

- Wavelength in free space: $\lambda\,(meter) = \frac{3E8}{freq(Hz)} = \frac{300}{freq(Mhz)}$
- Reflection coefficient vs. impedance: $\Gamma = \frac{Z - Zo}{Z + Zo}$
  - Z = Load impedance (Ω)
  - Zo = Characteristic impedance of the line (Ω)
- Voltage standing wave ratio: $VSWR = \frac{1 + |\Gamma|}{1 - |\Gamma|}$

where $|\Gamma|$ = magnitude of reflection coefficient

- Reflection coefficient:

$$K = \frac{VSWR - 1}{VSWR + 1}$$

- Return loss (dB) : -K (dB) = -20*LOG (K) VSWR (dB) = 20*LOG (VSWR)
- Ratio of power transmitted: $1\text{-}K^2$
- Loss due to VSWR : $-(1\text{-}K^2)$ (dB)=10*LOG $(1\text{-}K^2)$

Useful RF calculation

Free space attenuation or path loss between two points:

The calculation is made assuming ideal conditions, ie:

No reflection from terrain,etc

No atmosferic (climatic) attenuation

No obstruction within the first Fresnel ellipsoid

Use of isotropic antennas at either end of the path

[A]: Frequency - Frequency for calculation expressed in MHz

[B]: Distance - Distance between transmitting and receiving antennas, in Km

Free Space Attenuation (path loss) [dB]= 20 x LOG (A) + 20 x LOG (B) + 32.5

Signal ⇒ Field Strength

Signal field strength at the location of the receiving antenna, given the received signal level measured at the output connector of this antenna, across 50 Ohms.

[A]: Frequency- the frequency of the calculation, expressed in MHz

[B]: Rx antenna gain- the gain of the complete receiving antenna, expressed in dBd (which is the gain in dB referred to a half wavelength dipole) in the actual direction (horizontally and vertically) in which the transmitting antenna is situated.

[C]: Received signal(dBuV)- the received signal voltage expressed in dB relative to 1uV (microvolt) measured at the output connector of the receiving antenna across a resistive impedance of 50 Ohms

$$\text{Field strength [dBuV / m]} = 20 \times Log\left[10^{\left(\frac{C-B}{20}\right)} \times \left(\frac{2 \times \pi \times A}{300}\right)\right]$$

Parabolic Antenna Gain

Calculation of parabolic antenna gain, with the prime focus feed, with respect to an isotropic radiator (dBi).

[A]: Diameter - the diameter of the antenna, measured rim-to-rim directly across the parabolic reflector, expressed in metres

[B]: Frequency - the frequency for the calculation, expressed in GHz

[C]: Efficiency factor - efficiency factor for the illumination of the antenna. This takes into account the fact that the radiation from the feed does not illuminate the reflector uniformly. If the efficiency is not known, 0.55 may be assumed

$$\text{Parabolic antenna gain [dBi]} = 10 \times Log\left\{ C \times 4 \times \pi^2 \times \left[\frac{\left(\frac{A}{2}\right)^2}{\left(\frac{0.3}{B}\right)^2} \right] \right\}$$

Fresnel Zone Radius

Calculates the radius (minus axis/2 in metres) of the First Fresnel Ellipsoid at any point on the path. This is the zone which must be free from any obstruction in order to prevent attenuation, in excess of the free space value, caused by reflection from obstructions.

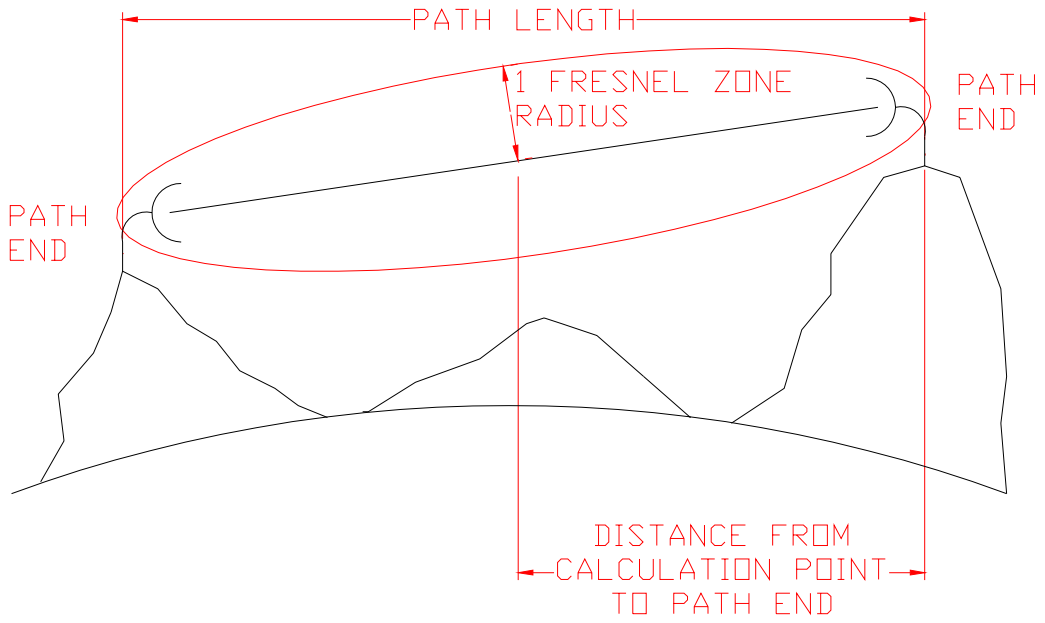
[A]: Path length - the direct distance between the transmitting and receiving antennas, measured in a straight line, expressed in Km

[B]: Distance from calculation point to path end - it is the distance from calculation point to the path end, measured horizontally in a straight line, expressed in Km.

[C]: Frequency - the frequency for the calculation, expressed in GHz

1st Fresnel zone radius over obstacle:

$$[\mathrm{m}] = \frac{\sqrt{\left(\frac{0.3}{C}\right) \times B \times 1000 \times (A - B) \times 1000 \times \left(\frac{1}{A \times 1000}\right)}}{2}$$



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