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Title Characteristics of Domestic UHF Receivers Affecting Channel Allocation Plans.

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Title: Characteristics of Domestic UHF Receivers Affecting Channel Allocation Plans.

Prepared by: This report is the result of a laboratory study carried out under the direction of a committee comprising engineers from all Sections of the Board's Engineering Division. The conduct of the measurements and analysis of the results were carried out under the supervision of Mr. J. Drew.

October, 1976

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Director, Engineering

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Characteristics of Domestic UHF Receivers Affecting Channel Allocation Plans

1. Introduction

For the formulation of frequency allocation plans for television services in UHF bands IV and V, it is necessary to have available details of certain essential characteristics of UHF television receivers. An investigation was carried out by the Engineering Division of the Board during December 1975 and January 1976 to determine the reactions of a variety of domestic UHF television receivers to various possible uniformly spaced* channelling patterns with a view to obtaining such data in quantitative form.

2. Structure of the Tests

It is necessary to know the following characteristics for an allocation plan to be determined:

(i) the ratio, at the input to the receiver, of wanted to unwanted signal levels of transmissions intended for reception in an area at which undesirable interference effects became manifest;

(ii) the adjacent channel rejection characteristics important under some allocation plans in the overlap between areas served from different locations.

The investigation was limited to allocation schemes employing uniform spacing between channels, on the intuitive assumption that uniform spacing, if practicable, offers maximum spectrum productivity. This aspect is of considerable importance when it is borne in mind that a substantial proportion of the available UHF broadcasting band must be reserved for filling in coverage gaps from existing VHF and possible new UHF parent transmissions in metropolitan areas. Maximum spectrum productivity in the Newcastle-Sydney-Wollongong areas is vital if provision is to be made for a reasonable number of additional high power UHF television services in the future.

In the formulation of the tests, availability of equipment limited the number of simulated services to four, but it was considered that the results using four channels would explore the characteristics of receivers to a degree sufficient to permit the performance with a larger number of channels to be predicted with reasonable accuracy. Within this limitation, the cases of uniformly spaced plans considered fruitful for examination are detailed in appendix 1(a).

3. Test Procedures

Full details of the test procedures adopted are given in appendices 1(b) and 1(c). Briefly the procedures involved:-

(i) each transmission in a group of four was selected in turn as the wanted transmission and the signal levels of the remaining three transmissions were varied in concert until just visible interference effects were noted;

Note: * The convention is adopted in this report of referring to the frequency difference between vision carriers of transmission intended to serve an area as channel "spacing". The frequency difference between vision carriers of adjacent channels in a continuous set of channels is referred to as channel "separation".

(ii) the procedure in (i) was carried out for wanted input signal levels of 1mV, 3mV and 10mV (across 75 ohms unbalanced). This range was selected as being representative of the signal levels likely to be experienced in the field situation;

(iii) following determination of the just visible point, signal levels were raised, to determine the levels at which interference became objectionable.

4. Receiver Sample

Tests were conducted on a total of 22 current design receivers ranging from simple inexpensive models to the more expensive models incorporating sophisticated operating facilities. The receivers came from Australian, European and Japanese sources and were considered to be reasonably representative of the population of UHF receivers in Australia. The receivers were supplied on the strict understanding that individual results would be confidential and that no receiver would be identifiable in any data published. Results of tests on individual receivers, however, have been made available to the suppliers of the receivers.

The receivers could be separated into two broad categories:-

(i) receivers incorporating varactor diode (varicap) tuners and push button channel selection (but with continuous tuning of the selected channel);

(ii) receivers incorporating continuous (as distinct from detent) mechanical tuners.

It will be noted that all receivers were capable of continuous tuning over the Australian UHF Television Band. This aspect was of considerable significance in the investigation as it allowed contemplation of a departure in the formulation of detailed allocation plans from the nominal 8MHz separation between contiguous carrier frequencies which is implicit in the UHF channel numbering scheme which has been adopted in Australia for the sake of uniformity with European practice in the marking of channels on receivers. It is for this reason that investigation of 7MHz separation between contiguous carrier frequencies has been included in the investigation (see appendix 1(a)).

5. Presentation of Results

The results are presented in graphical form showing percentages of the receiver sample which have an interference rejection ratio (i.e. ratio in decibels of unwanted to wanted signal levels) for just perceptible interference less than the value shown for the various uniform channel spacings. The results for the objectionable interference situation have not been included as the measurements showed that a reasonably constant 6 dB ratio existed between the just visible and objectionable criteria.

The graphs given in figures 1 to 3 relate to the test results from the 22 receivers without regard to tuner types, while those shown in figures 4 to 6 segregate the results for varactor diode and mechanical tuners.

The points shown in each curve are true experimental results, but the lines joining the points are for pictorial and identification purposes only. The validity of any interpolation between the true experimental results as depicted by these lines is subject to considerable doubt.

The thick horizontal lines at the top of each graph in figures 1 to 6 represent an experimental limitation arising from the maximum output level available from the equipment employed in the tests.

The presentation in figure 7 depicts the interference rejection ratio (for 50% of receivers) as a function of input signal level. This data is a representation of some of the data in figures 1 to 3 and is designed to display clearly the dependence of the interference rejection ratio on input signal level.

6. Discussion of Results

6.1 The issue which stands out clearly from the results is the strong degradation of performance caused by an increase in total input signal level. This is clearly depicted in figure 7. The reason for this dependence is considered to be the generally poor ability of UHF receivers to handle high total levels of input signal without incurring cross modulation, coupled with a generally mediocre radio frequency stage selectivity which gives little attenuation of unwanted signals prior to the essentially non linear frequency conversion stage.

Important conclusions to be derived from this deficiency are:-

(i) it may be necessary to take precautions when installing receivers to ensure that the level of input signal presented to the receiver is optimised as between cross modulation and noise degradation. This action will most probably be necessary for the lower performing receivers;

(ii) where significant UHF field strengths exist from transmissions not intended for the area, these unwanted signals might need to be attenuated by an appropriate directional receiving aerial. Again the poorer performing receivers will require more care.

6.2 24MHz spacing between channels is markedly inferior to the other useful spacings tested. This result is not surprising and no doubt reflects the existence of an image channel problem inherent with the 36.875MHz intermediate frequency adopted for use in Australia.

6.3 The minimum interference rejection ratios (based on the 1mV input signal, 50% of receivers case detailed in figure 7) for the various channel spacings, listed in order of performance, are:-

Spacing Between Channels	Minimum Interference Rejection Ratio dB	Remarks
28	22	
32	19	Spacing may not be usable unless local oscillator radiation is held within specified limits.
21	16	
14	15	Spacing cannot be used for more than 5 channels due to image problem.
16	12	Spacing may not be usable unless local oscillator radiation is held within

Bearing in mind that the received signals are more likely to differ between channels as the frequency separation between channels increases, it is reasonable to conclude:-

(i) that all of the spacings listed (with the exception of 16MHz and 32MHz, which experience local oscillator radiation problems) are potentially useful if the circumstances are such that the transmissions intended for the area are the only transmissions that need to be taken into account; 14MHz is however limited to five working channels;

(ii) the preferred channel spacings are 28MHz and 21MHz, with 14MHz also being very useful if the number of transmissions ultimately required is limited to five.

6.4 The tests for adjacent channel operation reveal that there is only a very small difference in performance between channelling arrangements using 8MHz and 7MHz separation between vision carriers, and that there is no significant penalty incurred by the adoption of a 7MHz channelling arrangement in lieu of the 8MHz arrangement adopted in Europe and nominally adopted in Australia to achieve uniformity in channel numbering.

6.5 It is pertinent to note, following the conclusions of 6.3 and 6.4 above, that a 7MHz separation arrangement has marked advantages for use in Australia, all the preferred channel spacings being multiples of 7MHz.

6.6 The degree of interference experienced by particular receivers will depend on the signal level differences between channels serving the area. These differences can only be accurately gauged by field tests, but it is to be expected that the levels may differ considerably even in the optimum case where all transmissions are radiated from a common antenna. The results of the receiver tests indicate that while the higher performing receivers involve few problems the lower performing receivers might experience difficulty at some receiving locations. The implication is that whatever spacing is chosen, it can be expected that the lower performing receivers will not attain optimum results at all locations. (The adverse effects may of course be minimised by care in the installation of the receive antenna to minimise signal level differences). The field tests envisaged in Section 7 will provide detailed information on the incidence of the more extreme cases of signal level difference, reported from overseas, as being as high as 20 dB.

6.7 As the primary cause of interference between wanted transmissions appears to be cross modulation in the receiver input stage, improvement of receiver performance in this regard (at least for the lower performing receivers) would be the most productive in improving the quality of UHF television reception. The tests indicate that improvement is desirable in the case of many varactor tuned receivers and that such improvement is achievable (as instanced by the higher performing varactor tuned receivers).

7. Conclusion

In summary, the tests on receivers have revealed:-

(i) that a channelling arrangement based on 7MHz separation between vision carriers is to be preferred;

(ii) that improvement in performance of some receivers is desirable as optimum reception is unlikely to be achieved by all of the receivers tested under certain field conditions, irrespective of the allocation plan adopted;

(iii) that except in the case of the higher performing receivers, care will be necessary in the installation of receivers in the field to:

(a) control the signal level fed to the receiver to optimise performance between cross modulation and noise;

(b) minimise the signal level differences between channels.

(iv) the desirability of conducting field studies to determine the extent and severity of signal level variations between transmissions likely to be encountered.

8. Acknowledgements

The cooperation and assistance of Philips Vision and Sound and Telecom Australia in making equipment available for the conduct of the tests and of the members of the Receiver Working Party in providing receivers for test is gratefully acknowledged.

Channel widths of both 7MHz and 8MHz are considered.

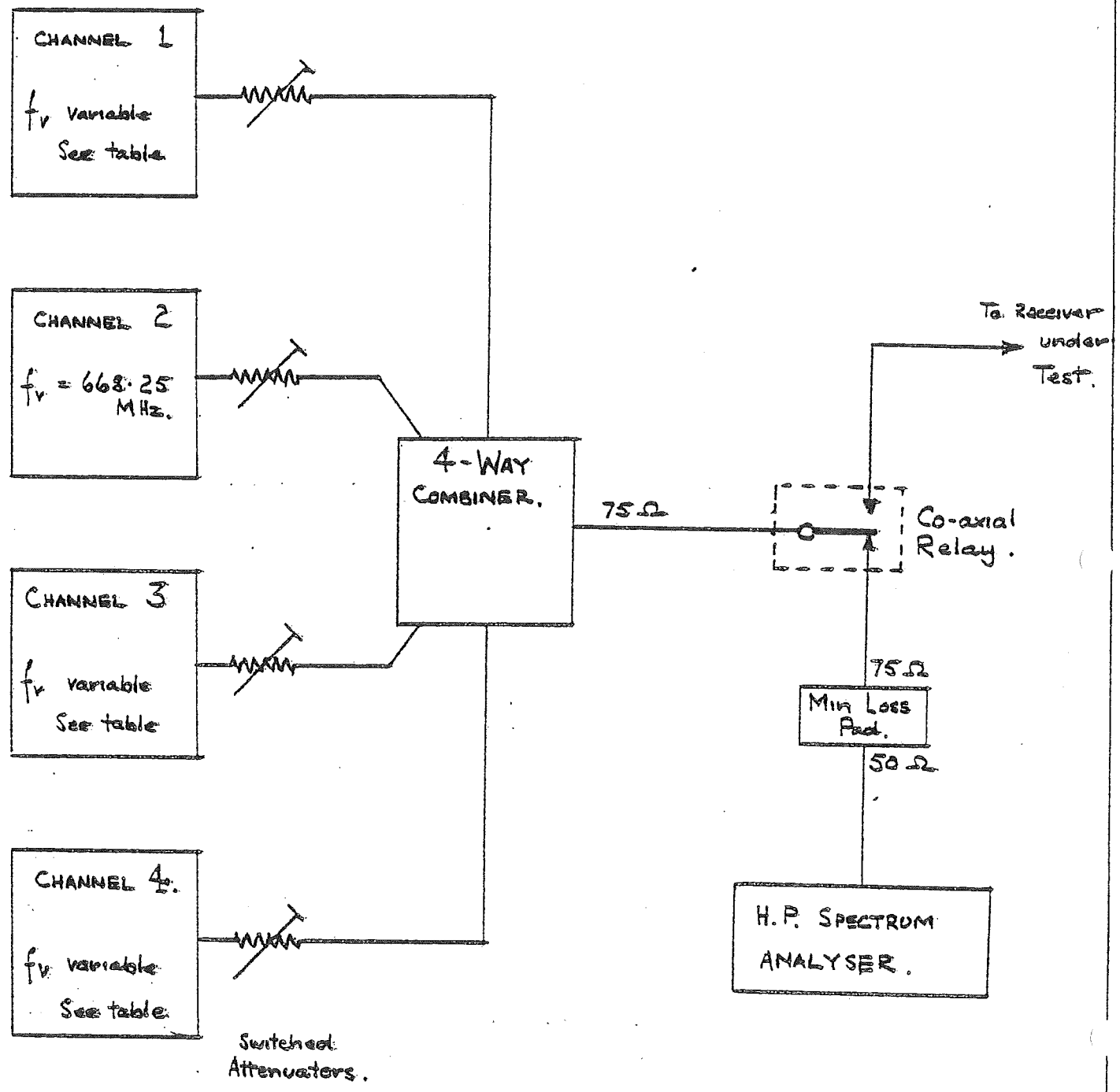
FREQUENCY TABLE

A. For 8MHz CHANNEL SPACING

	Vision carrier separation (MHz)			
	8MHz (n=1)	16MHz (n=2)	24MHz (n=3)	32MHz (n=4)
CHANNEL 1: fv = (N-n8)	660.25	625.25	644.25	636.25
CHANNEL 2: fv = N	668.25	668.25	668.25	668.25
CHANNEL 3: fv = (N+n8)	676.25	684.25	692.25	700.25
CHANNEL 4: fv = (N+n16)	684.25	700.25	716.25	732.25

B. For 7MHz CHANNEL SPACING

	Vision carrier separation (MHz)			
	7MHz (n=1)	14MHz (n=2)	21MHz (n=3)	28MHz (n=4)
CHANNEL 1: fv = (N-n7)	661.25	654.25	647.25	640.25
CHANNEL 2: fv = N	668.25	668.25	668.25	668.25
CHANNEL 3: fv = (N+n7)	675.25	682.25	689.25	696.25
CHANNEL 4: fv = (N+n14)	682.25	696.25	710.25	724.25



Appendix 1(b) EQUIPMENT CONFIGURATION.

APP 1 (C.)

EXPERIMENTAL PROCEDURE

The equipment configuration was devised to simulate four completely independent television transmission channels operating in the U.H.F. bands. See the diagram App 1 (b). Each R.F. Signal was vestigial sideband in form, with a vision/sound carrier spacing of 5.5 MHz. All video and audio modulating signals were derived from separate sources and in the case of video were asynchronous.

Three channels were capable of being operated at any desired frequency in the U.H.F. bands. The fourth channel was operated at a fixed frequency. The frequency table is shown as App 1 (a)

The outputs of each system were combined and fed via adjustable attenuators to the 75ohm antenna input of the receiver under test. Baluns are used where necessary.

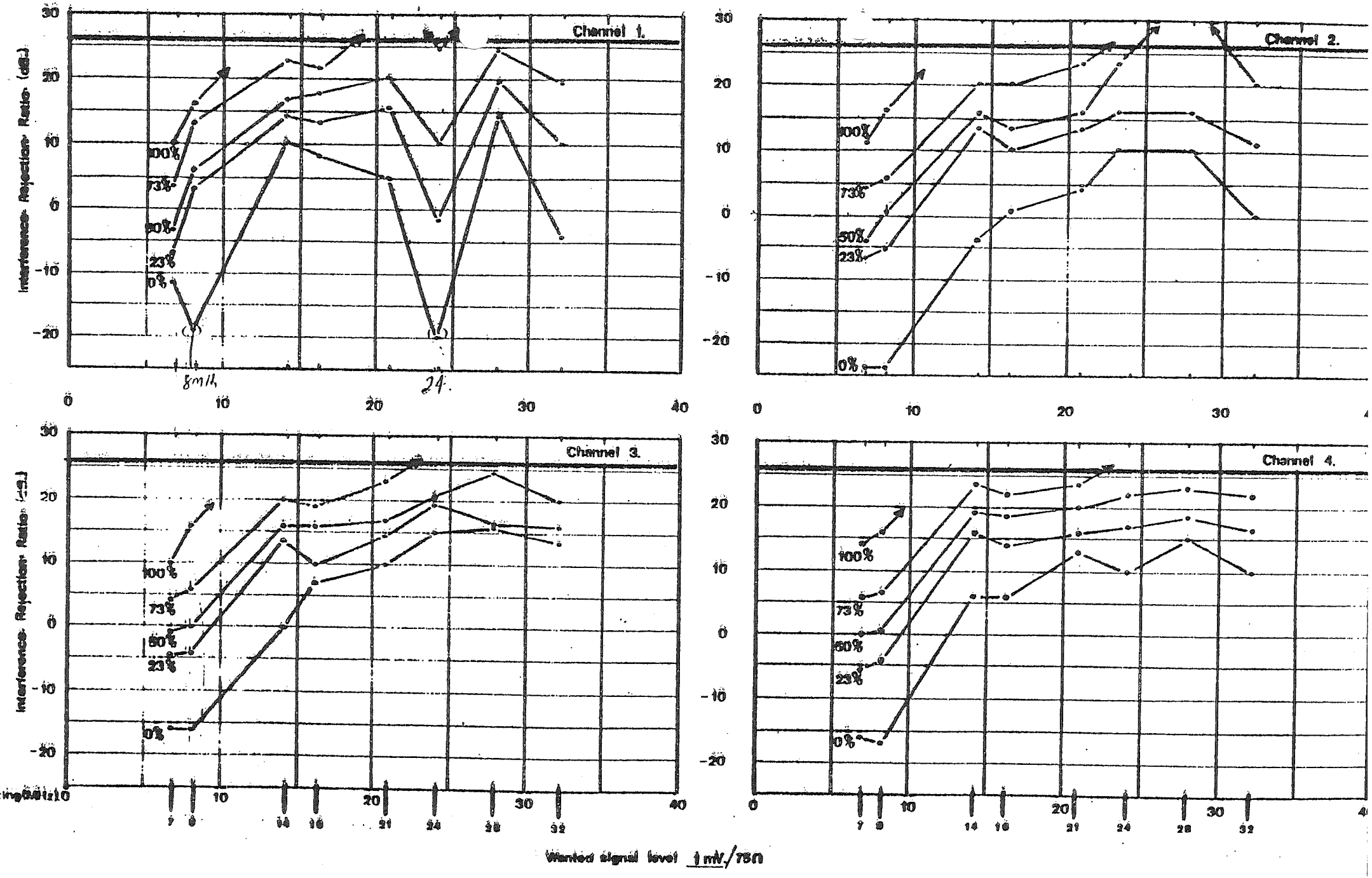
The frequencies of each channel were set as required, the receiver was tuned to a selected channel. The input level for this channel was set to 1mV (during sync). The levels of the three unwanted channels were then increased together, (to a max. of 20mV) until a just noticeable impairment was viewed on the wanted channel picture. The level was noted at this point.

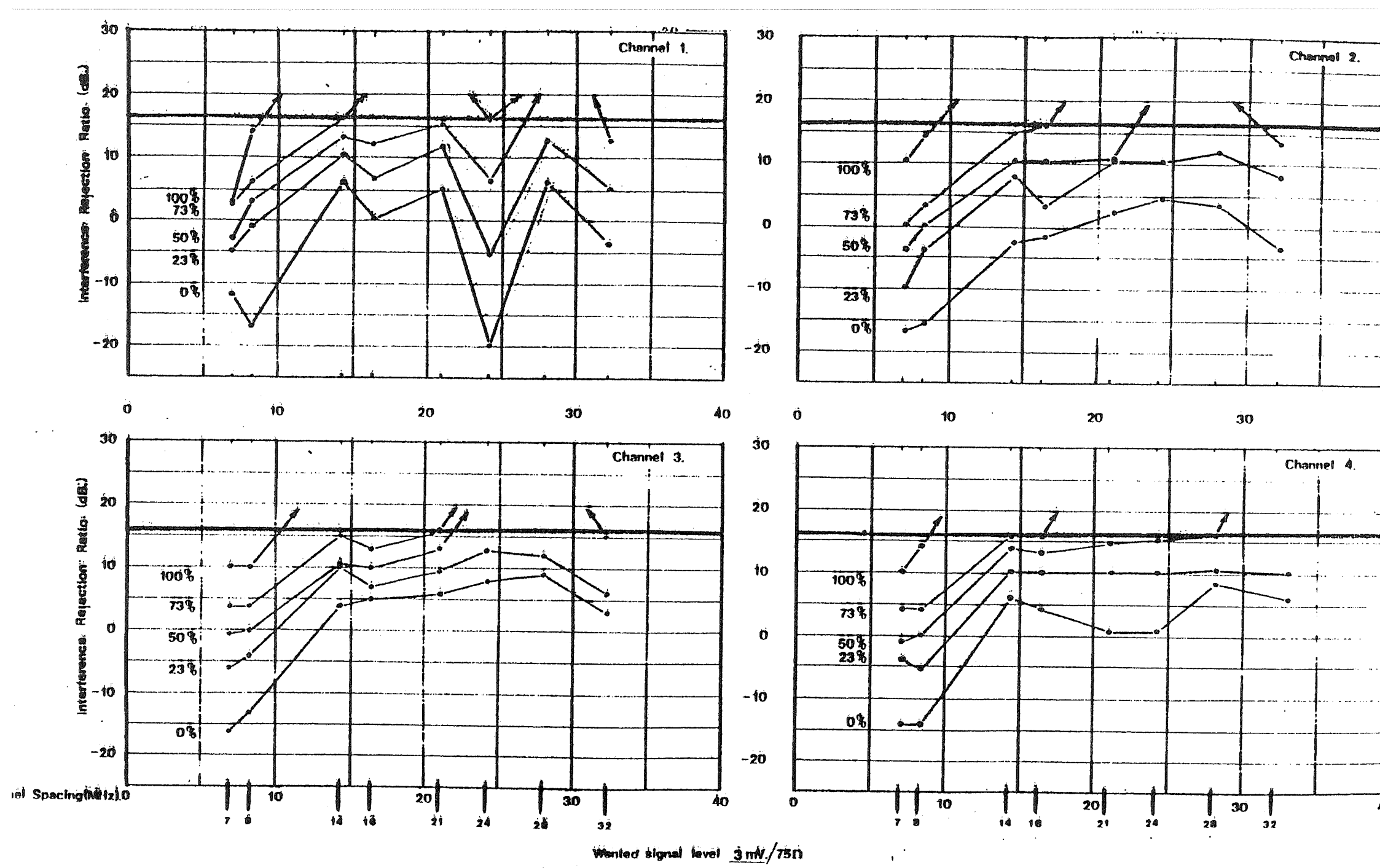
The level was then increased further until the impairment was considered objectionable. This level was also noted, and an investigation as to the mechanism of the impairment was then conducted and recorded.

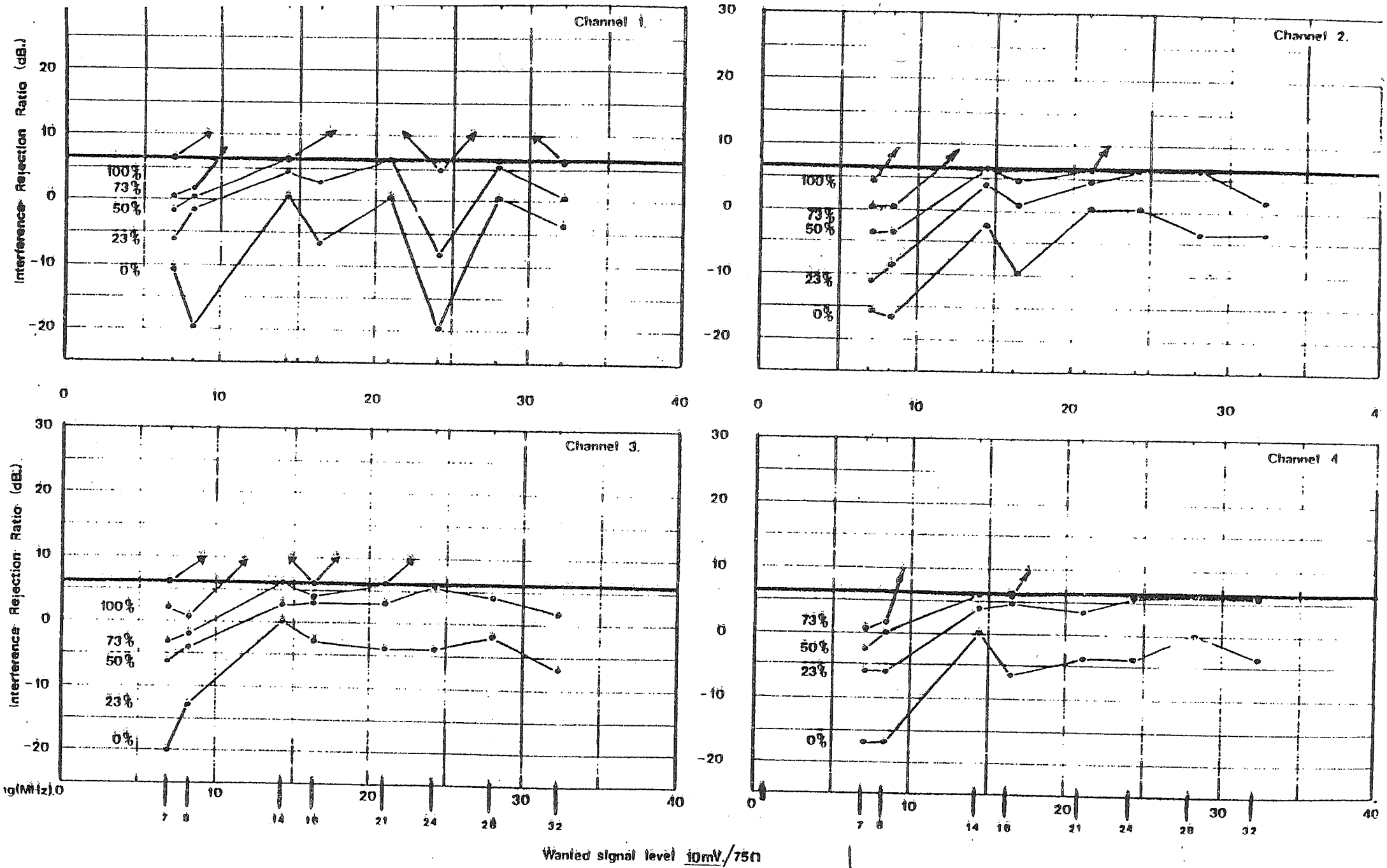
This procedure was repeated for a wanted channel input of 3mV and 10 mV.

Without changing channel frequencies, a new wanted channel was then selected and the above procedure repeated.

When all four channels have been selected and tested, a new set of channel frequencies obtained from the frequency table App 1. (a) were set up and the procedure repeated.


Channel 1.
Channel 2.
Channel 3.
Channel 4.
Interference Rejection Ratio (dB)
100%
73%
60%
50%
23%
0%
8mH
24.
Spacing (MHz)
7
9
14
16
21
24
28
32
Wanted signal level 1 mV/75Ω


Channel 1.
Channel 2.
Channel 3.
Channel 4.
Interference Rejection Ratio (dB.)
100%
73%
50%
23%
0%
30
20
10
0
-10
-20
0
10
20
30
40
7
8
14
16
21
24
28
32
Wanted signal level 3 mV./75Ω


Channel 1.
Channel 2.
Channel 3.
Channel 4
Interference Rejection Ratio (dB)
100%
73%
50%
23%
0%
Wanted signal level 10mV./75Ω

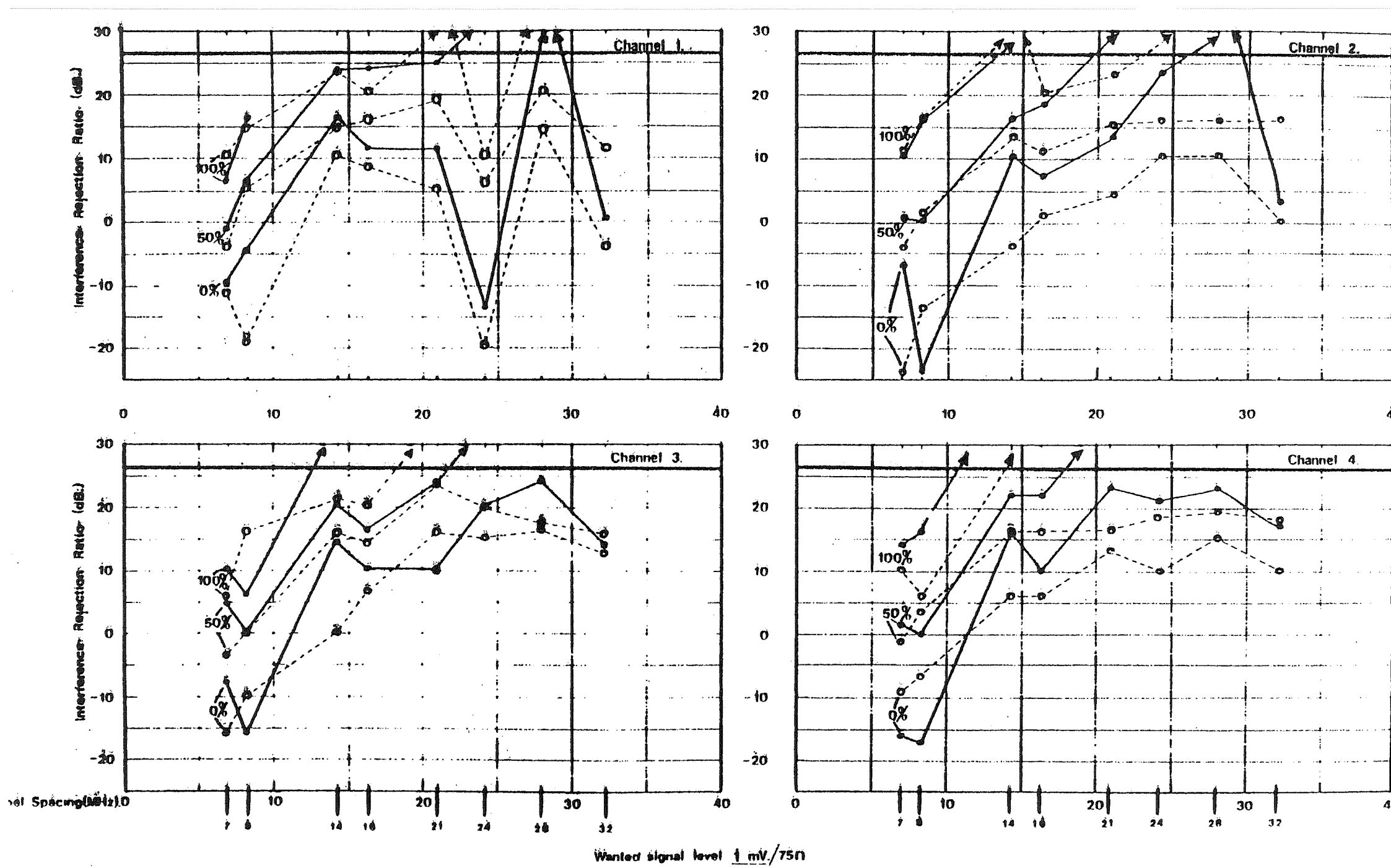
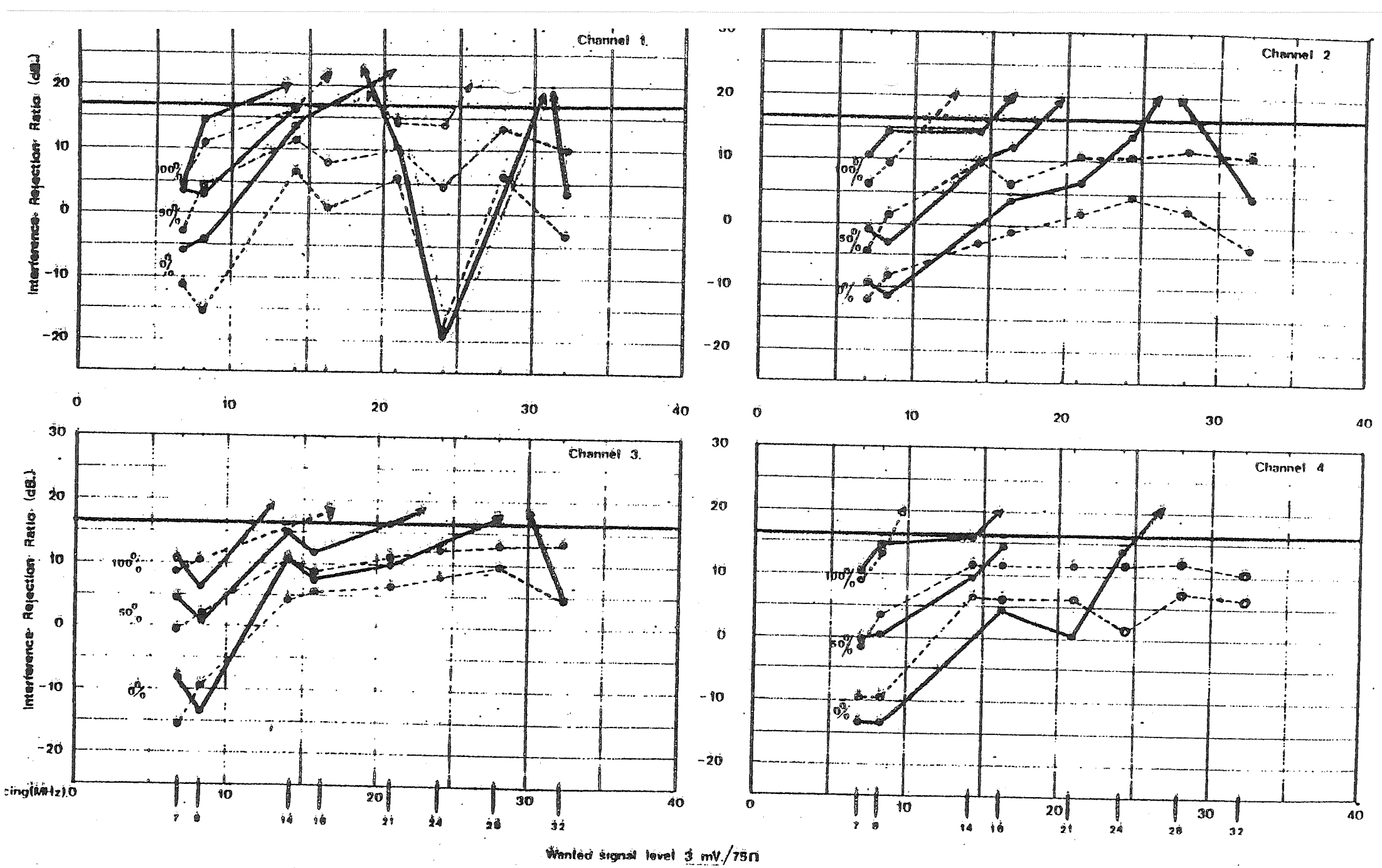


Fig: 4 Percentiles of the sample of varactor and mechanical tuner type receivers separately


Channel 1.
Channel 2
Channel 3.
Channel 4
Interference Rejection Ratio (dB.)
100%
90%
50%
0%
Wanted signal level 3 mV./75Ω
mechanical tuner
varactor

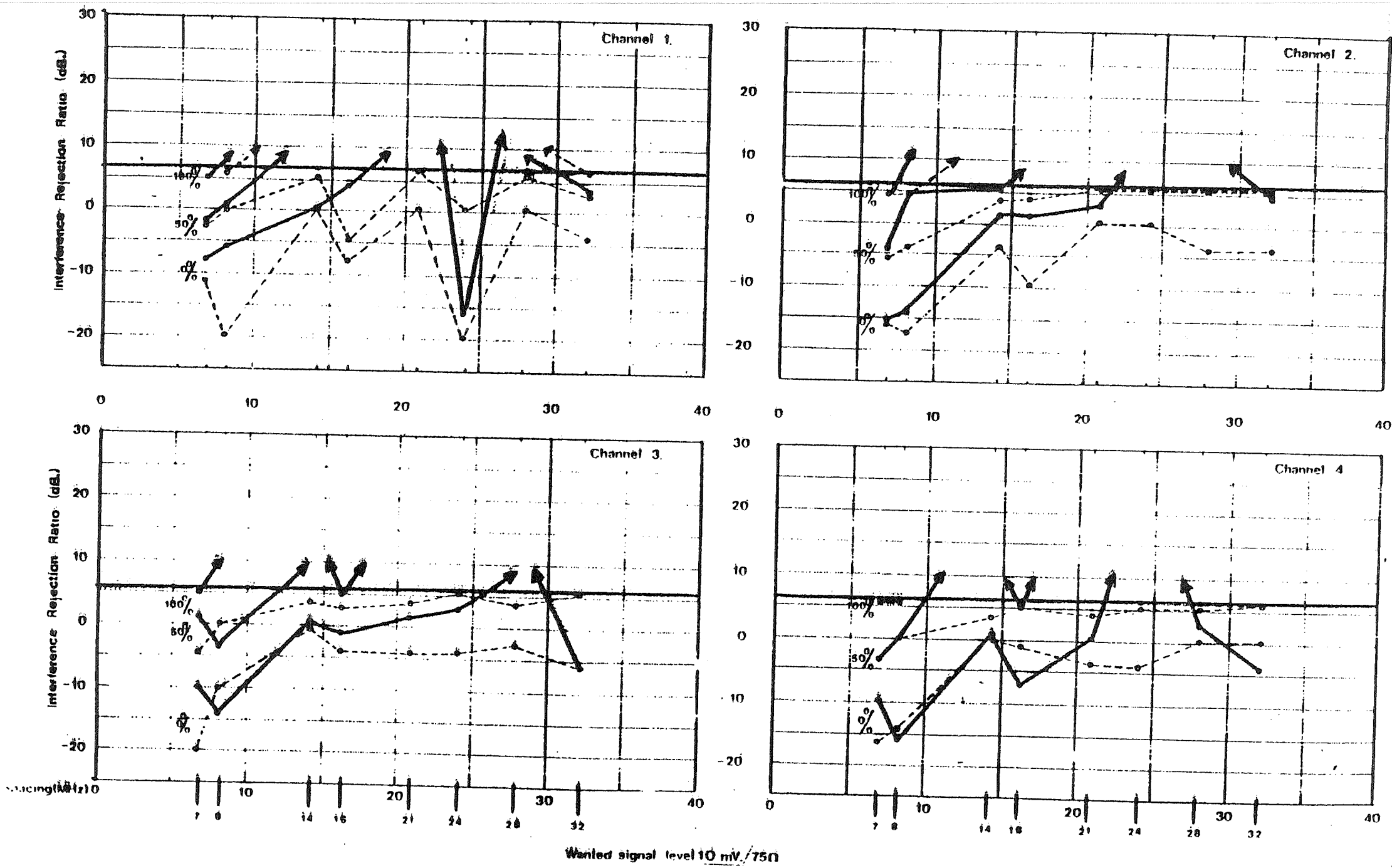
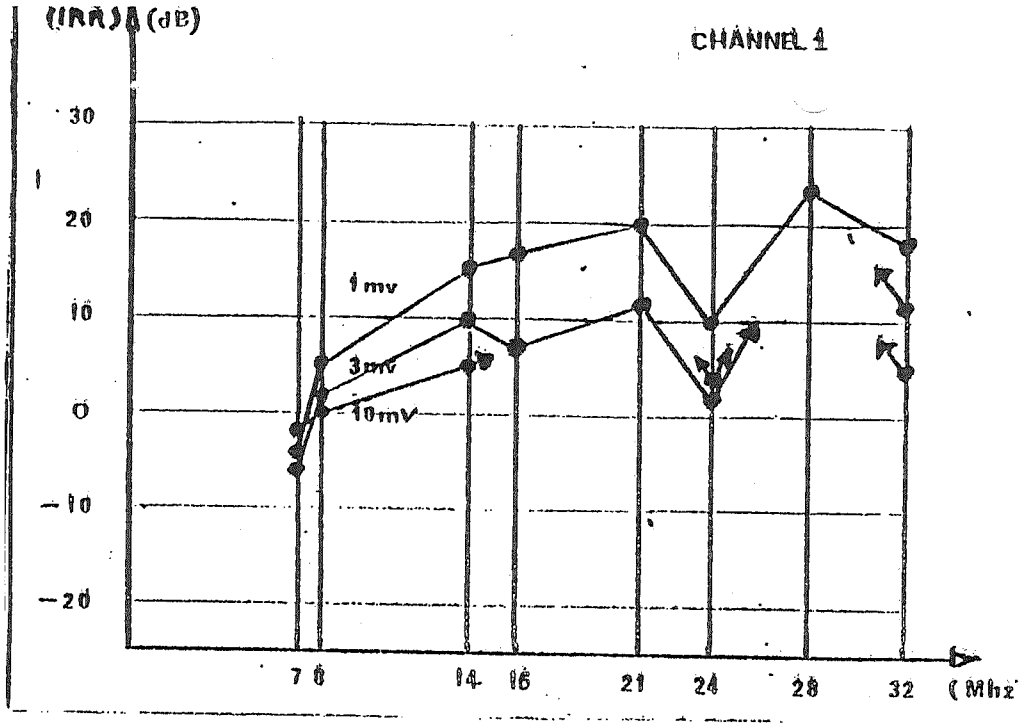
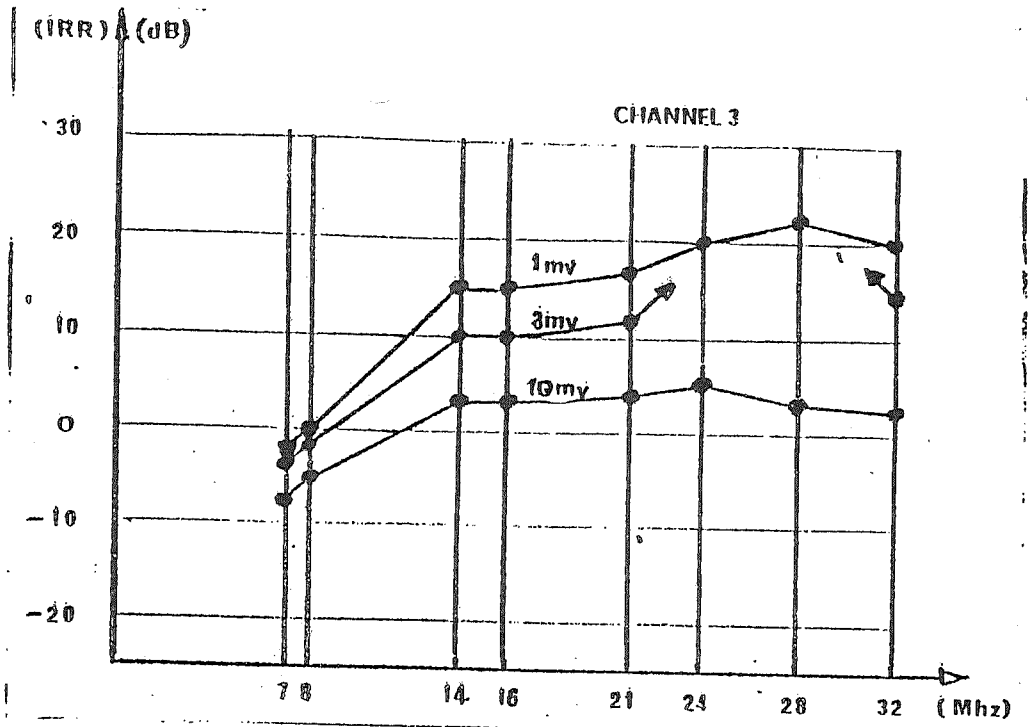
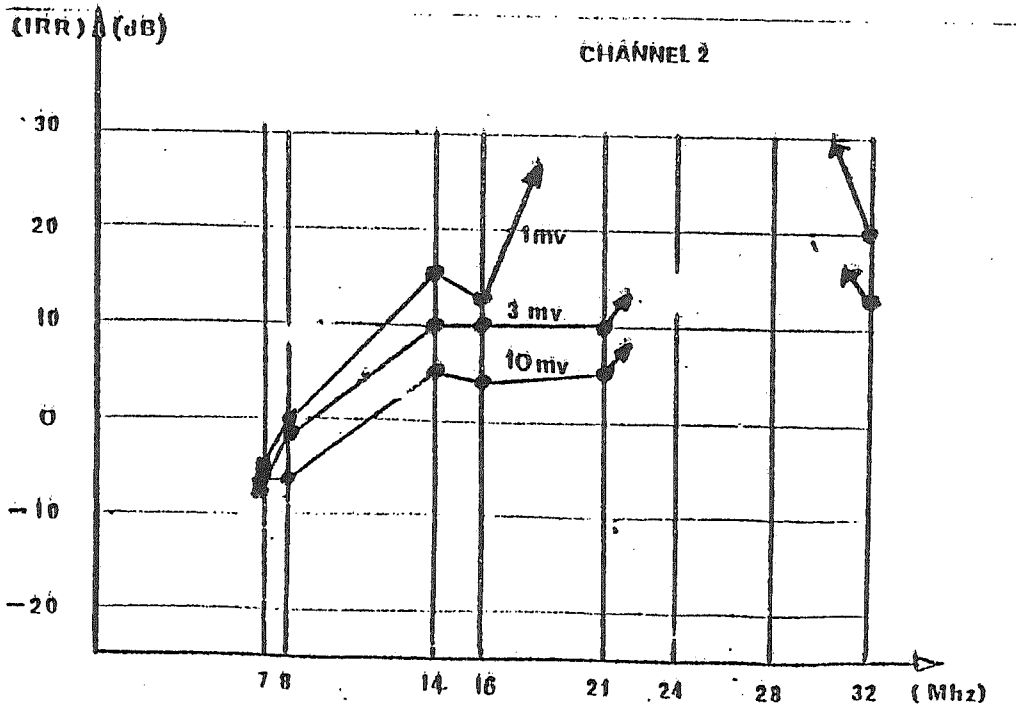
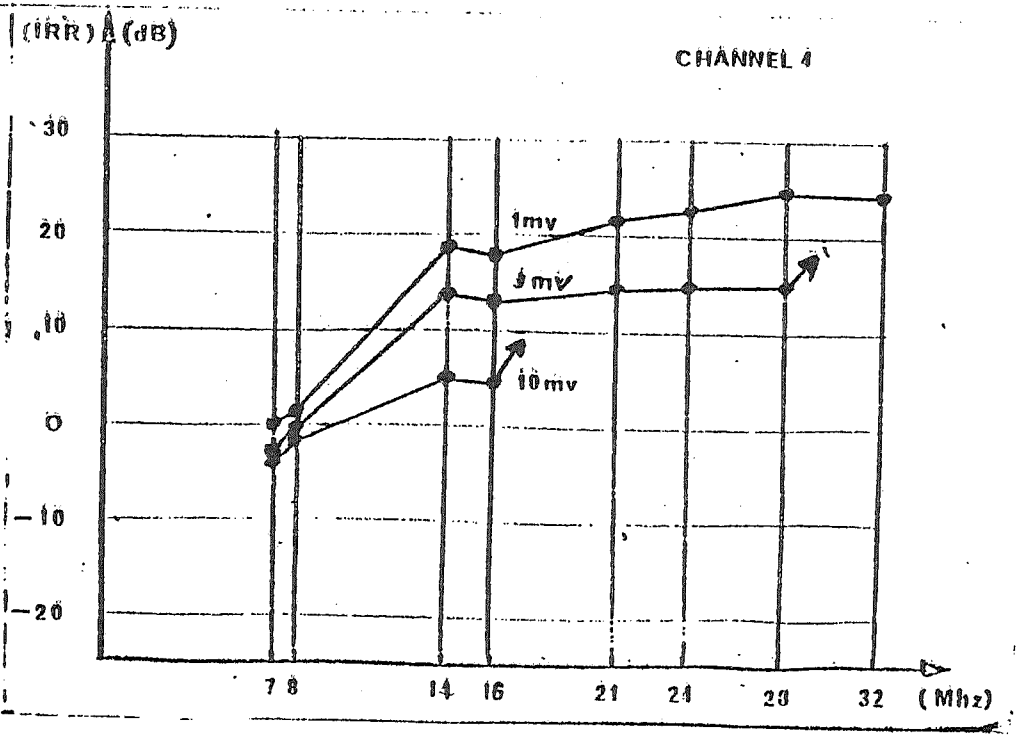


Fig 8 Percentile of the sample of varactor and mechanical tuner tune receivers


(IRR) (dB)
CHANNEL 1
30
20
10
0
-10
-20
1mv
3mv
10mv
7 8
14 16
21 24
28
32
(Mhz)


(IRR) (dB)
CHANNEL 3
30
20
10
0
-10
-20
1mv
3mv
10mv
7 8
14 16
21 24
28
32
(Mhz)


(IRR) (dB)
CHANNEL 2
30
20
10
0
-10
-20
1mv
3 mv
10mv
7 8
14 16
21 24
28
32
(Mhz)


(IRR) (dB)
CHANNEL 4
30
20
10
0
-10
-20
1mv
3mv
10mv
7 8
14 16
21 24
28
32
(Mhz)