

Über die Messung und Bewertung von Störwirkung von Geräuschen

[On the measurement and weighting of interference effect of noise]

Fernmeldetechnische Zeitschrift, 1954, 7, 1, pp. 25 - 32.

By Ernst Belger

Translated by Hans-Martin Burmeister.

This English translation is accompanied by an OCR and graphic scan of the original article in German and is part of a research project: <http://realfield.com/anm/history/>

The History of Low-Level Audio Background Noise Measurement

Especially techniques of assigning a single value to low-level background noise of various types, according to the degree to which humans find it annoying, disturbing or interfering (in German: **Störgeräusch**), with particular reference to the relative merits of RMS detection (dBA) and quasi-peak detection (CCIR 468 and related technical standards).

This project includes a zip file of the figures below and other documents, including a 1953 paper by Ernst Belger which covers much of the material this article concerns, also with an English translation.

Robin Whittle – rw@firstpr.com.au – Melbourne, Australia, 12 July 2013.

Summary in English and French

In the first part of this article there is examined the interfering effect of chopped or wobbled sine tons and of a thermal noise of a terz [third octave] band width as a function of the frequency in presence of useful modulation (music) under conditions as in a private dwelling. Young testers with good hearing capability listened to music of high quality.

Compared with the psophometer curve according to CCIF 1949 a considerable higher interference sensitivity resulted from frequencies above 5 kHz. In the second part there was ascertained the necessary signal-to-noise ratio for music transmissions of high quality.

Dans la première partie de cet article l'effet des perturbations des sons sinusoïdaux hachés ou wobulés et d'un bruit thermique avec une largeur de bande d'une tierce en fonction de la fréquence en présence de modulation utile (musique) dans les conditions comme dans un appartement privé, est examinée. Des personnes d'essai jeunes et bien capables d'ouïr ont écouté de la musique d'une bonne qualité.

En comparaison avec la courbe du psophomètre selon CCIF 1949, on a trouvé une sensibilité plus haute contre des perturbations au-dessus de 5 kHz.

Introduction

Although various studies on the disturbance resp. on the volume of noise have been undertaken for decades, a final clarity has not been established yet, neither about principles nor about the apparatuses, as can be seen from the contradictory results.

On the other hand, for a long time there has been a general urgent need for a measurement capability, not least in electronic signal transmission technology. Interfering noises appearing in audio-bandwidth transmission lines degrade transmission quality directly and under circumstances even the intelligibility. The provisions reducing them require a considerable economic effort. Checking their effectiveness by measuring is therefore essential.

The emphasis is on the "Noise Voltage Measurement", i.e. a measurement to reflect the subjective impression of interference.

Complicated procedures hardly come into question for measurements of this type, that require *Beranek's* method of volume measurement, a split-up of the frequency range into multiple ranges with subsequent computational or graphical composition. Rather a direct indication is desirable. The current devices almost exclusively contain a weighting filter, which takes into account the different ear sensitivity in the various frequency ranges and a subsequent amplifier with display instrument that performs the correct evaluation over time (continuous tones or pulses).

While it was initially assumed that volume and interference effects are proportional to each other, and frequency weighting was undertaken according to equal loudness curves, over the years the understanding has established that the relationship between the two variables is not as simple, particularly at higher frequencies. For the first time clear expression is given by CCIF recommended psophometer-curve in 1949, with a more critical weighting of frequencies above 1000 Hz. They resulted from tests by the American Telephone and Telegraph Company, investigating the disturbance of noise under conditions like found when listening to the radio in the living room (*fig. 1*).

Since this curve is referred to as "preliminary recommendation" only, the West German broadcasters carried out experiments on behalf of the Working Group on NWDR with the aim to assess this curve. Results of the studies were submitted to German Postal Office as documentation for a report to the CCIF.

Regardless of these investigations, subsequently the noise ratio necessary for high-quality broadcasting was examined, using the noise meter 3/U 311-313 made by the company Siemens & Halske (J 77) that had been introduced to the German Post Office and the West German broadcasters.

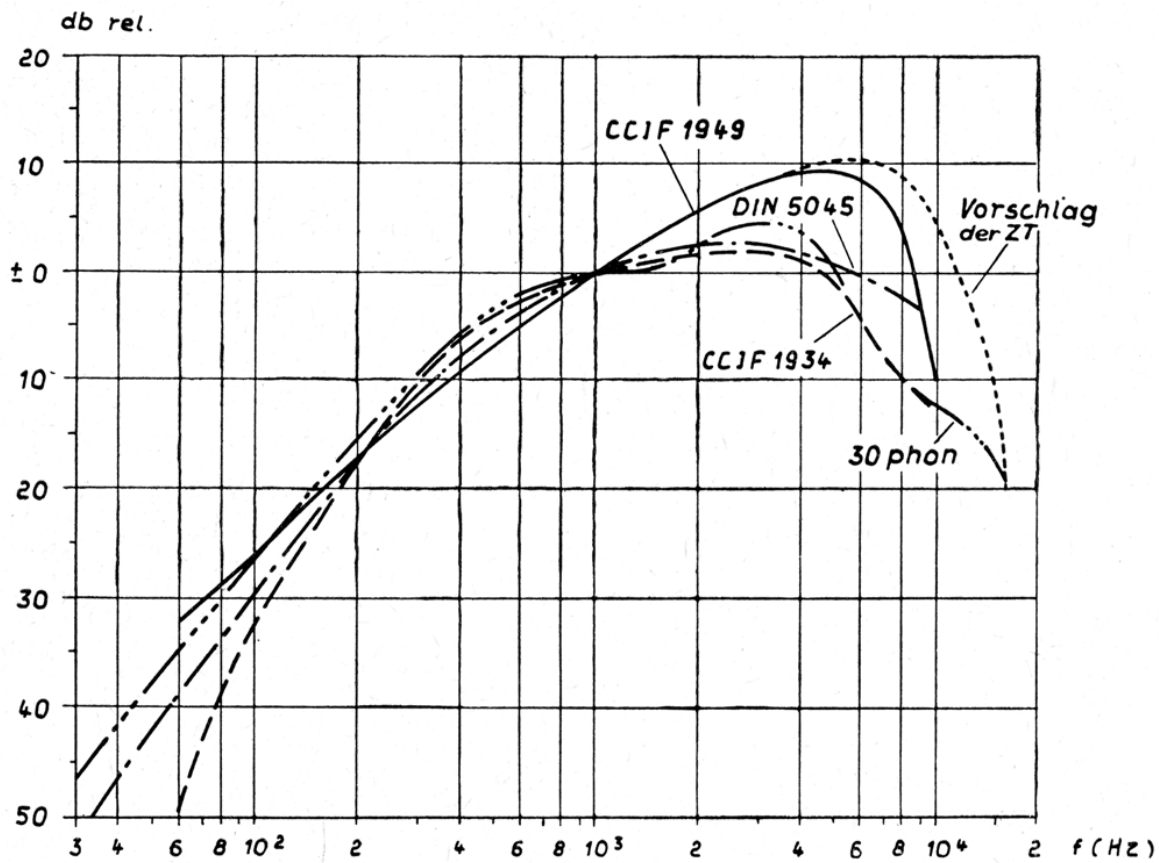


Bild 1. Einige Bewertungskurven zur Geräuschspannungsmessung

Fig. 1. Some weighting curves for noise voltage measurement

Vorschlag = suggestion, ZT ("Zentraltechnik" central technology group)

I. On the frequency dependency of the disturbance effect

1. Test conditions

It was aimed to carry out the observations under the same conditions (useful modulation, room noise level), similar to the tests of the ATT, like observers

Emphasis was placed on the critical aspects, as for example in case of quieter passages of quality music broadcast in quiet rooms. In order to assess what changes occur under various conditions, tests were performed also in noisier rooms and with a little less sensitive music. Very insensitive transfers, such as dance music and big orchestra were ignored because no matter how the rating curve may be constructed, is not expected to impact the reception in this type of transmissions if the installation complies with the requirements the above-mentioned critical modulation modes provide.

Before the experiments, the observers were explicitly instructed that they had to evaluate the interference effect and not the audibility or the volume of the noise. A certain psychological difficulty, however, remains basic in these experiments: While the listeners normally concentrates on the program and fail to hear any noise if possible, here they will be reminded by the need of adjusting the noise level or to judge it in any other way, and distracted by the program. It is possible that the results are distorted by this incorrect setting in some degree. However, in my opinion there is no practically feasible method of measurement with this phenomenon disabled.

Also, of course, there is some certain arbitrariness in the selection of the noise, the volume, the characteristics of the room noise and especially the useful modulation. However, if you will ever come up with acceptable effort to a weighting curve, you will need to take such possible errors into account.

A block diagram of the experimental apparatus used is shown at *fig 2*.

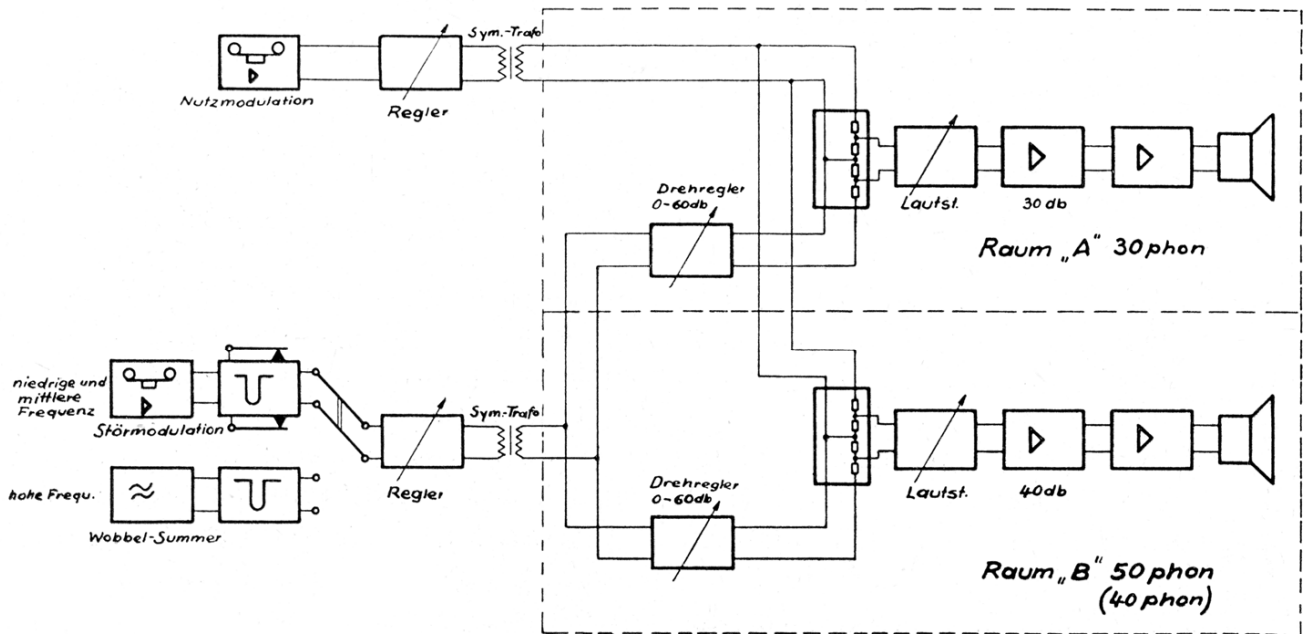


Bild 2. Blocksaltbild der benutzten Versuchsapparatur

Fig. 2. Block diagram of the test set-up

Nutzmodulation = useful modulation; **Regler** = attenuator; **Symm-Trafo** = symmetric transformer; **Lautst. (Lautstärke)** = volume; **Raum** = room; **Drehregler** = control; **niedrige und mittlere Frequenz** = low and midrange frequency; **hohe Frequ.** = high audio frequency; **Störmodulation** = interfering modulation; **Wobbel-Summer** = warble / beat frequency oscillator.

In detail the tests were performed under the following conditions:

Useful modulation

Soft passages of quality piano, organ and string music were chosen as useful modulation, namely motives with the lowest possible dynamics to keep the variance in the experimental results small due to fluctuating volume of useful modulation. Each test subject could adjust this useful modulation to his normal radio listening volume.

In the just described type of modulation was the risk that the subjects would select too much volume in disregard of their natural level. So a short piece of music with great dynamics to adjust the desired volume. The subsequent actual test modulation was quiet then, necessarily at its correct volume, which was not changed during the series of measurements.

In selecting the music, it was found that most of the tape recordings had a noise at the quiet passages, which normally would not bother, but could make their use questionable for this specific purpose. So there were special recordings made on high quality tapes, the modulation was increased by 15dB. The background noise of the tape became virtually inaudible by a corresponding attenuation in playback. Since the maximum level remained still more than 5 dB below full scale, there were no non-linear distortion to worry about. By using a high quality speaker cabinet with omnidirectional tweeters it was ensured that no undue distortion occurred at this point in the transmission chain.

Disturbing modulation

The disturbing noise was played close to natural conditions via the same loudspeaker. It consisted of a third octave band of random noise and a pure tone periodically interrupted with 2 cycles per second. The selection of such motives may appear artificial, considering the disturbing noises in practice. A partitioning of a natural noise by narrow-band filters leads to noises that are composed in various ways from steady tones and impulses. Using such noise would give an uncontrolled mix of frequency response and impulse characteristics – not to mention that such a narrow band would be unlike a real case.

Frequencies at 50, 100, 200, 400, 800, 1600, 3200, 6400, 8000 and 12500 Hz were used. These noises were also recorded on tape, at a level -12 dB below maximum. This avoided nonlinear distortion, on the other hand it kept tape hiss below the level of perception. The 50-Hz-noise passed a third octave filter, because small overtones were audible that might have led to a falsification of the results.

It was observed that sensitivity was substantially higher in relation to high frequencies, than was to be expected after the CCIF 1949 curve, so there was a the closer investigation of this range in a second set of frequencies, which overlapped first in a larger frequency range in order that sufficiently many

tests were done. The frequencies 3.5, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16 kHz were used. Within this range we measured with narrowly swept pure tones (sweep rate 6.25 cycles per second, frequency deviation 100 Hz), since the third-octave noise contains too wide a range for a clean measurement and a sine wave only gave locally too much variation in response [in-room response of sine waves].

The warbled tones were filtered, to avoid eventual difference tones of the BFO (beat frequency oscillator, German: "Schwebungssummer") in frequency ranges with more ability to disturb.

The disturbing noises could be reduced by the test subjects by means of an adjustable attenuator in steps of 2.5 dB to the point that it no longer affected the enjoyment of the music played. The adjusted values were recorded. The question of how long a noise must be presented to the observers had been cleared in preliminary experiments. It was found that 15 s was sufficient to set the desired attenuation value without haste. At prolonged periods, the concentration was affected, particularly at participants with fast response.

At the tests it could be observed that the test subjects not only relied on their ears but got influenced by external influences. So they tended to turn the control into a position that did not differ much from the one before too much, even if this did not meet the presented level. In order to avoid such influencing the control knob was designed in a way that the test subjects could not read the damping, but they had a rough sense for the angular position and tended to set a near value at the following tone. That led to leveling the curve with equal sound pressure at all frequencies. Hence it was necessary to predetermine the rough trend of the damping, like known from contemporarily use and earlier tests, and leave only the correction of these values to the test subjects. This does not mean illegitimate manipulation of the test subject, but a transformation of the iteration method known from mathematics.

Furthermore it became apparent that the test subjects were more tolerant of the first disturbing noise in a series compared with the following: the same noise was attenuated by the test subjects about 3dB less at the beginning of a series than in any other position. In order to avoid this error, the noises were presented in alternate order.

Room noises

Half of the tests were accomplished in a quiet room with 30 phons noise level, the other half in a noisier room with 50 phons. Since such a room with approximately constant noise level was not available and strong temporal fluctuations would have increased the dispersion of the results of measurement unnecessarily, the level in a calmer room was artificially increased. To achieve this, in addition over a second loudspeaker a tape recording of the road noise of a busy street was played, whereby the upper frequency range was electrically reduced, in order to replicate sound absorption by closed windows.

The second loudspeaker was placed in a wider angle from the first, seen from the listeners position, to enable a better separation of sounds, like room noise and received programs come in from varying directions in living rooms.

Frequency response of loudspeakers and room had been equalized electronically. As deviations from linear response affect the result of the test substantially, the whole transmission chain from tape recorder resp. warble tone generator to the room was controlled in a way, so the sound pressure of the original disturbing noise was checked by a microphone at the listening position.

The use of the original disturbing noise is also important because room and speakers have very narrow frequency dips and peaks and interpolation from adjacent frequencies would lead to quite significant errors. Since the location of the observer during the experiments is of course not defined very precisely, the average of the values resulting from six adjacent positions of the microphone was used in the determination of the residual frequency response.

Test Subjects

The observations were implemented by 20 ladies and gentlemen at ages between 20 and 30 years. The males came from technical occupations, the females from trade.

Their hearing sensitivity had been examined in advance with an audiometer and cases of hearing loss had been excluded. The upper frequency range was provided by a beat frequency oscillator and a headphone set as a provisional audiometer, and the same frequencies, like later used in the tests, were chosen to check the test subjects' hearing.

2. Results

The results from the tests are shown in *fig. 3 to 9*. The ordinate indicates the mean attenuation values adjusted by the twenty test subjects *), whereas a correction of frequency response had been undertaken.

*) As it turned out with the tests that there were no noteworthy differences between the results from male and female test subjects, the mean of all test subjects was calculated.

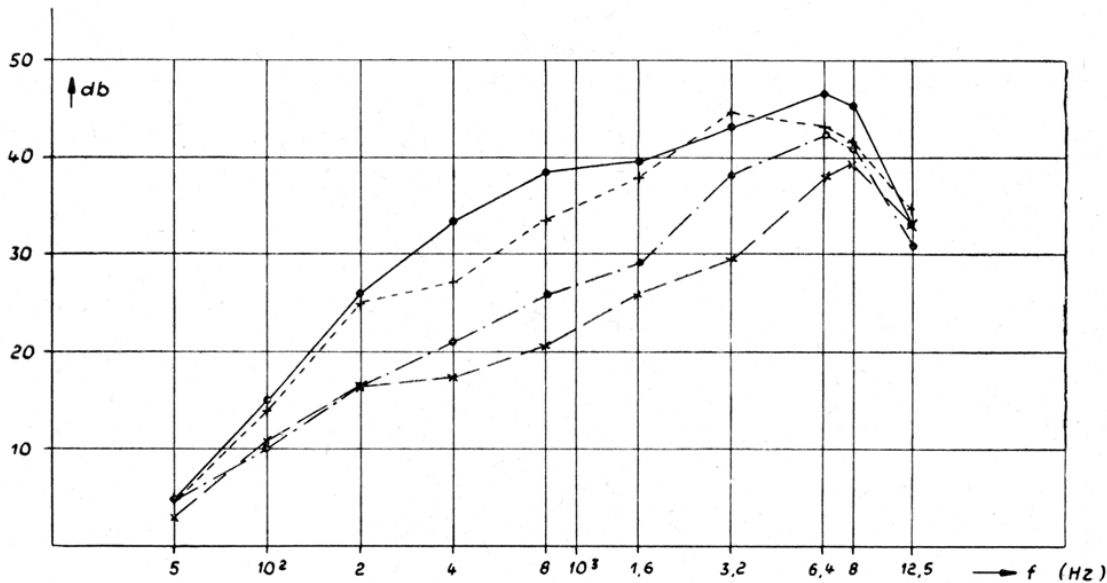


Bild 3. Von den Versuchspersonen im Mittel geforderter Dämpfungsverlauf der Störmodulation (Terzrauschen) in einem Raum von 30 phon Grundgeräusch bei verschiedenen Nutzmodulationen.

— Pause ... Klavier — · — Orgel — — — Streichinstrumente.

(Die db-Skala bezieht sich hier, wie bei allen folgenden Bildern von Teil I, auf die benutzte Versuchsanordnung, bedeutet also nicht etwa den Abstand vom Nutzpegel oder von der Aussteuerungsgrenze)

Fig. 3. Averaged by test subjects required damping of noise modulation (1/3 octave noise) in a room with 30 phon noise level at various useful modulations.

— Pause ... piano - . - organ - - - strings.

(The dB-scale refers here to part I and the test set-up used, like with all following figures, it does not signify any ratio to useful signal or modulation limit)

Fig. 3 shows the susceptibility to third octave noise third octave noise with various music in a quiet room (30 phon).

As expected, the sensitivity is maximal in the modulation pause, not much less with piano music as a result of the pauses between the notes. However, it is much lower with organ and even less with string music, as both cover the disturbing noise with their long-drawn tones, which usually pass each other without a break. The effect is particularly evident in the mid-frequency where

the focus of the useful modulation is and in the adjacent higher range, because lower cover higher frequencies more than vice versa. The sensitivity at the highest and lowest frequencies is hardly affected by the modulation.

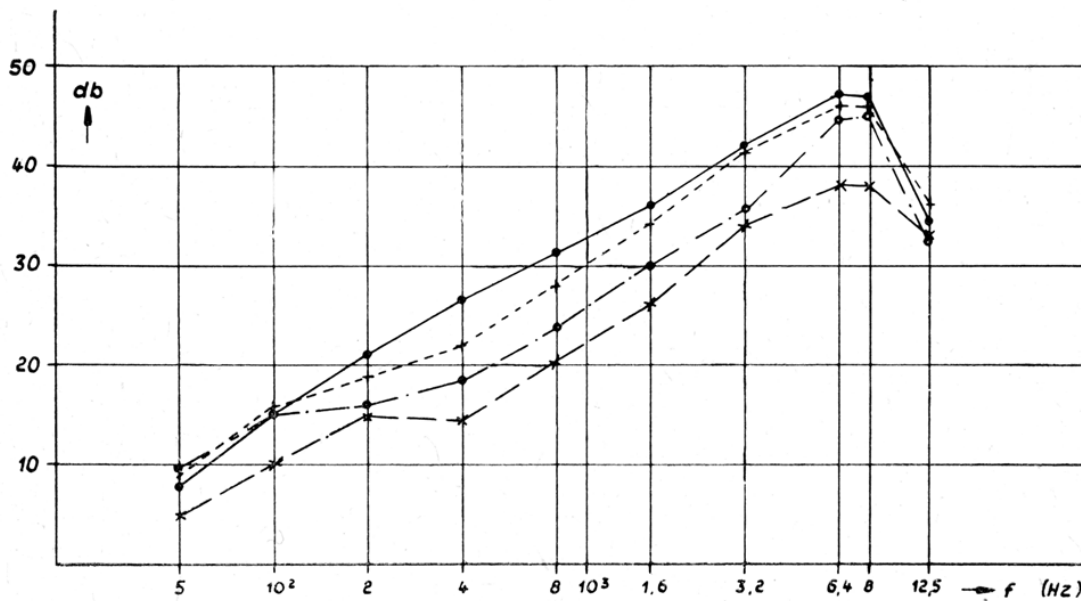


Bild 4. Geforderter Dämpfungsverlauf für ein Terzrauschen bei einem Raumpegel von 50 phon.

— Pause . . . Klavier — · — Orgel — — — Streichinstrumente

Fig 4. Required damping with 1/3 octave noise at 50 phon room level.

— Pause . . . piano - . - organ - - - strings

Fig. 4 shows the influence of a room with a higher noise level (50 phon) with the same useful and disturbing modulation. The room noises act in the same sense as the useful modulation, more with missing or "transparent" modulation than with the already strongly obscuring organ or string music.

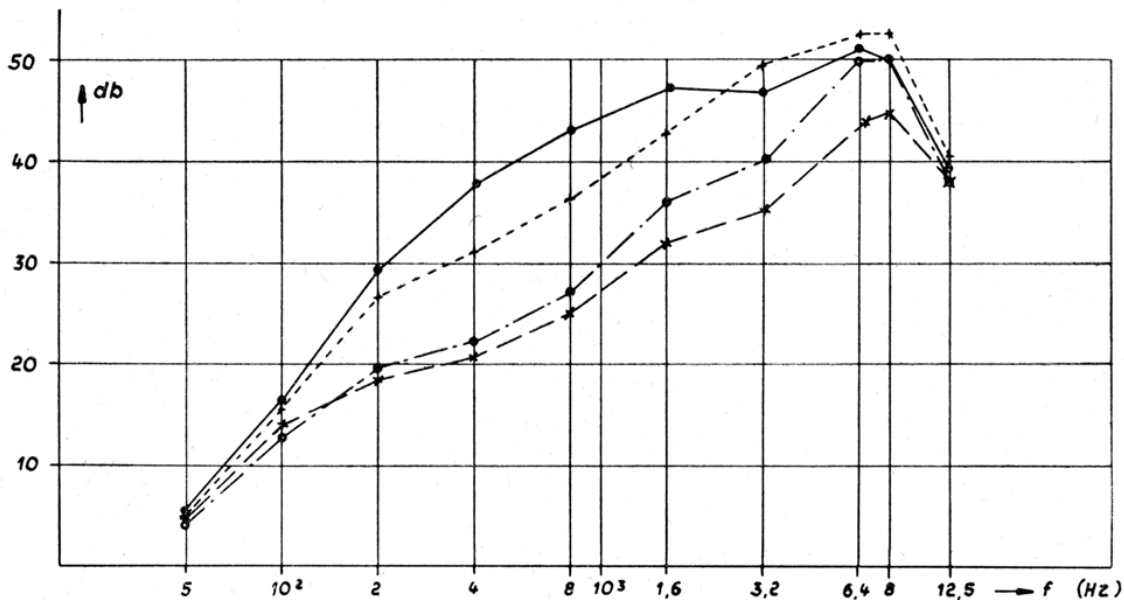


Bild 5. Geforderter Dämpfungsverlauf für einen zerhackten Sinuston, Raumpegel 30 phon.

— Pause ... Klavier — · — Orgel — — — Streichinstrumente

Fig. 5. Required damping response for chopped sine wave, room level 30 phon.
 — Pause ... piano - - organ - - - strings

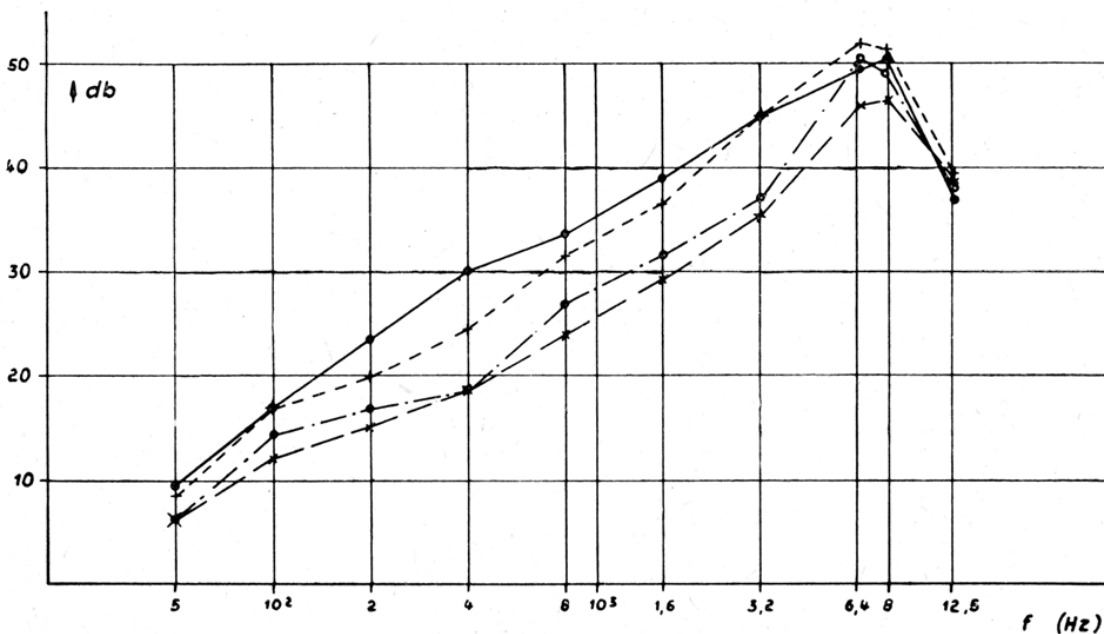


Bild 6. Geforderter Dämpfungsverlauf für einen zerhackten Sinuston, Raumpegel 50 phon.

— Pause ... Klavier — · — Orgel — — — Streichinstrumente

Fig. 6. Required damping response for chopped sine wave, room level 50 phon.
 — Pause ... piano - - organ - - - strings

Fig. 5 differs from *fig. 3* only by the nature of the interference modulation, like *fig. 6* from *fig. 4*. A noticeable difference within these pairs appears only

at the high frequencies where the ear is more sensitive to the chopped sine wave than is to the third octave noise.

The upper frequency range, measured using the same useful modulation, but with a warble as disturbing modulation is shown in [fig. 7](#) (30 phon room noise) and in [fig. 8](#). (50 phon room noise). Again, the effect of the room level gets lost in the transition to the highest frequencies.

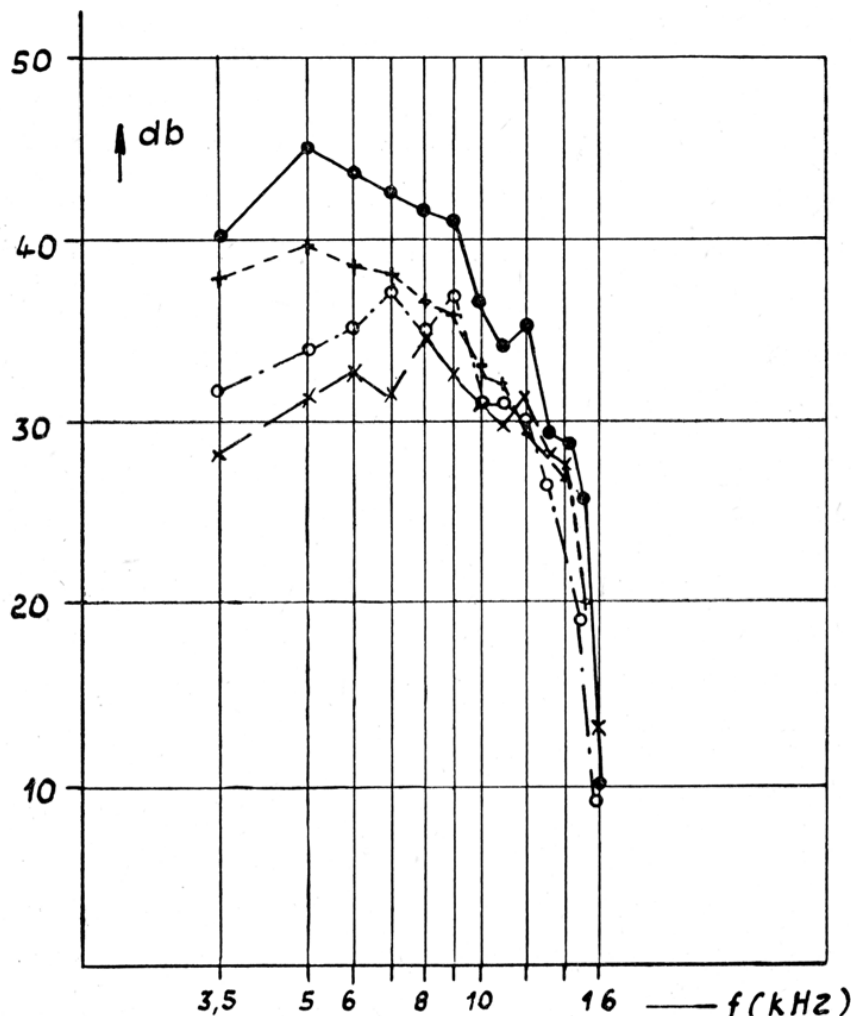


Bild 7. Geforderter Dämpfungsverlauf für einen gewobbelten Sinus-ton, Raumpegel 30 phon.

— Pause . . . Klavier — · — Orgel — — — Streichinstrumente

Fig. 7. Required damping response warbled sine wave, room level 30 phon.

— Pause . . . piano - - - organ - - - strings

In [Fig. 7](#) the two ranges are put together (the average from [fig. 3, 4, 5, 6](#) and the average from [fig. 7 and 8](#)), wherein they were shifted towards each other so the overlap range was covered best (3,5 to 12,5 kHz).

A comparison with the CCIF weighting curve of 1949 shows the satisfying compliance in lower and medium range, while above 6 kHz the disturbing effect of the present experiments is much stronger than could have been expected after the CCIF curve. The newly determined response for this range can be indicated approximately by the dashed curve. The difference between

the two curves might be explained by also older people attending in the American tests, the CCIF- values based on.

At white noise a more pronounced weighting of e.g. treble range gives a + 3 dB raised noise voltage.

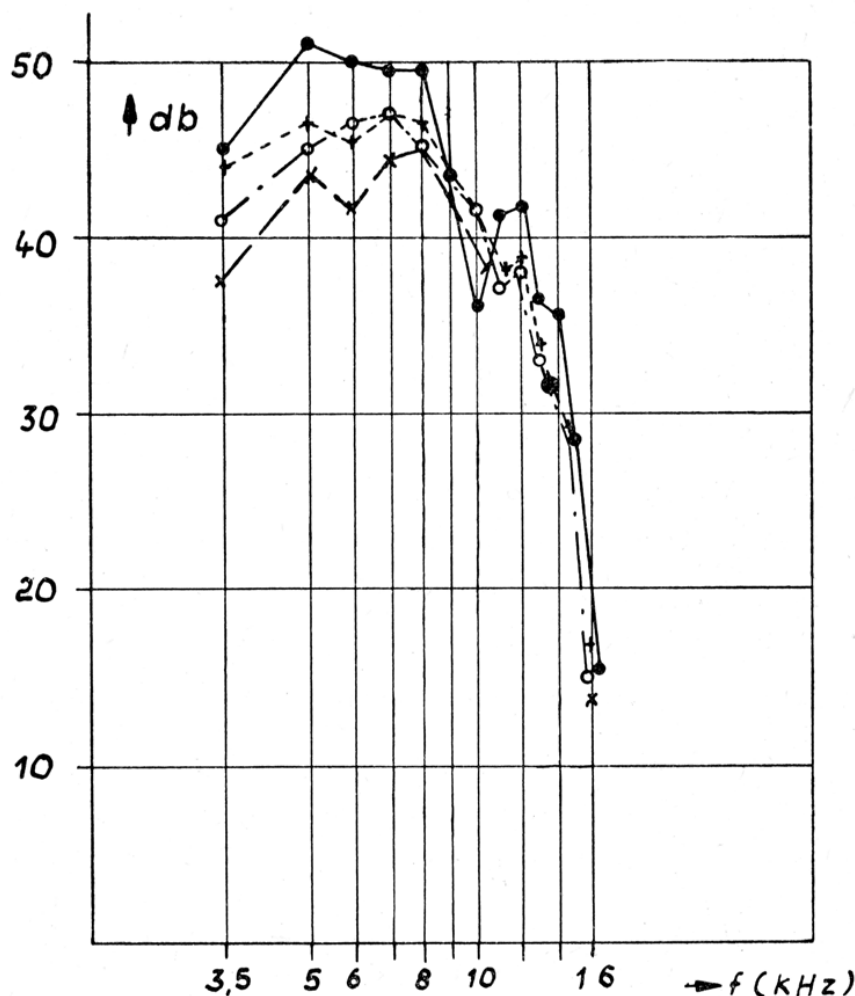


Bild 8. Geforderter Dämpfungsverlauf für einen gewobbelten Sinuston, Raumpegel 50 phon.
 — Pause ... Klavier — · — Orgel — — — Streichinstrumente

Bild 8. Fig. 8. Required damping response for wabled sine wave, room level 50 phon.
 — Pause ... piano - . - organ - - - strings

The medium and lower range could be simulated with good approximation by a straight curve with a slope of 6 dB per octave. According to the experimental results, in this range the CCIF curve 1949 corresponds with the situation in the modulation pauses in quiet rooms, while the straight curve reproduces sensitivity in rooms with moderate noise levels at sensitive music (piano).

Seen from the practical aspects the CCIF-curve offers the advantage, that nothing needs to be adapted in lower and medium frequency range at the existing devices, while a straight curve could have been implemented more easily (simple RC- combo).

To estimate the accuracy of the determined values, the usual error analysis was used, there was of course nothing to speak of an "error" in the usual sense. The following values were obtained:

<i>average „error“ of</i>	lower frequency range	medium frequency range	upper frequency range
individual measurement	5,3 dB	6,8 dB	8.0 dB
mean of curves 2 - 5	1,3 dB	1,6 dB	2,2 dB
overall mean value	0,7 dB	0,8 dB	1,1 dB

The volume level of the music adjusted by the test subjects was in a quiet room (30 phon noise level) average 54 phon with an average deviation of 2,4 phon, in a noisier room (50 phon noise level) 63 phon with an average deviation of 3 phon.

II. Studies of the required noise ratio

1. Experimental conditions

The first test series aimed only for the determination of the frequency response for the weighting filter. The investigation of the required noise ratio was performed in a second test series, since for this purpose the actually occurring noise promised a better approximation to the practice than the somewhat artificial noises that were required for the determination of the frequency response.

While the meter (type of rectification, time constants) plays only a minor role at the determination of the frequency response, it is crucial in determining the required noise ratio, since disturbing noises are used here, which are various mixes of continuous tones and impulses. Thus, the values obtained here are not general, they apply only on the psophometers of Siemens & Halske (3 U 311/113) used here. The device is introduced to the German Post Office and the West German radio stations and is named J77 at the latter. There is a peak indicator with an integration time of a few ms and a decay time constant of 350ms. The frequency weighting follows the CCIF curve of 1949.

The following eight disturbing noises were used:

a) *Noise (hiss) of an amplifier*

From energy aspects, this contains a strong power supply hum, but due to its low frequency it did not disturb the ear. (The V 72 in use is a standard microphone amplifier for studio applications, strictly regulated by IRT Institute for Radio Technology, Germany, <http://www.irt.de/IRT/publikationen/braunbuch/V72.PDF>).

b) *Inductive coupling of mains hum*

The hum basically consisted of a 100-Hz-tone with a considerable portion of higher harmonics. The 200Hz-component dominated subjectively.

c) *Switching noise of relays and power line hum on a line*

For the ear the impact of impulsive switching noise was crucial.

d) *Crosstalk of a long-distance call on a phone line*

The noise on the line was mixed with a hum. The clearly audible voice outweighed all background noises.

e) *Crosstalk from accordion music on a line*

Even at higher level the hum was still perceived, but the annoying music dominated here too, despite the substantial weighting of high frequencies from crosstalk

f) *Noise of magnetic tape (normal FeO₂ tape)*

In the energy spectrum the range around 150 Hz, but The frequency band around 4000 Hz was most evident for the ear.

g) *Noise in VHF- FM-radio*

The selected noises appear, if the transmitter remains non-modulated and a „jammer“ interference transmitter works in the same channel with 1000-Hz-modulation. That causes a number of sine waves disharmoniously spread, with continuously changing pitch as the transmitters never keep frequency absolutely stable. The audible impression was some high and unpleasant swirling or chirping.

h) *Sine wave 1000 Hz*

The tone was introduced primarily for calibration and measuring purposes.

In the remaining points the test procedure of part 1. was maintained and only slight changes were introduced. Thus the string music used so far, which was quite non-transparent, compact and hardly differed from organ music concerning its sensitivity to noise was replaced by a more transparent recording. Furthermore the artificial road noise was lowered from 50 to 40 phons, after a majority of the test subjects reported that under such noisy conditions they would not listen to broadcast transmissions nor to high-quality music.

The measurement of the disturbing noise was done again in the sound field.

This was required to eliminate the inevitable remaining frequency response of loudspeaker and room. The complex nature of most natural disturbing noise permits no computational correction like with the artificial interferences.

One might argue that transient noises receive some smoothing by the direct and manyfold reflected signal paths between the loudspeaker and the microphone, that might change the reading of the J77 compared with the direct electrical measurement.

Still it can be expected that this deviation is small compared with the deviations in frequency response.

A more specific measurement of the aforementioned effects is desirable.

While the frequency response of the instrument (method of rectification, time constants) matters less, it turns decisively important when defining the required signal-to-noise ratio, since noises were used here, consisting of mixed steady tones and impulses. So the measurements were accomplished in parallel with the J 77 and with an RMS instrument (thermocouple) according to actual international standards. The comparison with the results of the subjective test permits as well an evaluation of these meters concerning their suitability for measuring noise levels.

Both cases were weighted after CCIF 1949. Additionally a comparative measurement with a J 77 was accomplished, with an upstream four-pole network whose filter curve was adapted to stronger weighting of treble according to part1.

Since many natural interferences are temporally not constant, but have considerable dynamics, even slow-acting instruments give a varying reading, which complicates the measurement.

For the presented investigation the reading was taken while loud noise passages, since these might be crucial for the interfering effect. On the contrary isolated peaks were ignored, because according to experience only repeated impulses are perceived as disturbing.

Since the weighted signal-to-noise ratio relates to the full sound level of the program material, the result of the tests depends directly on the sound engineers' program level setting. Hence several sound engineers were asked for their opinion, which level they would set for the selected program. Fortunately the variance of their data was so small that the mean value could be used as a basis for the tests.

2. Results of measurements

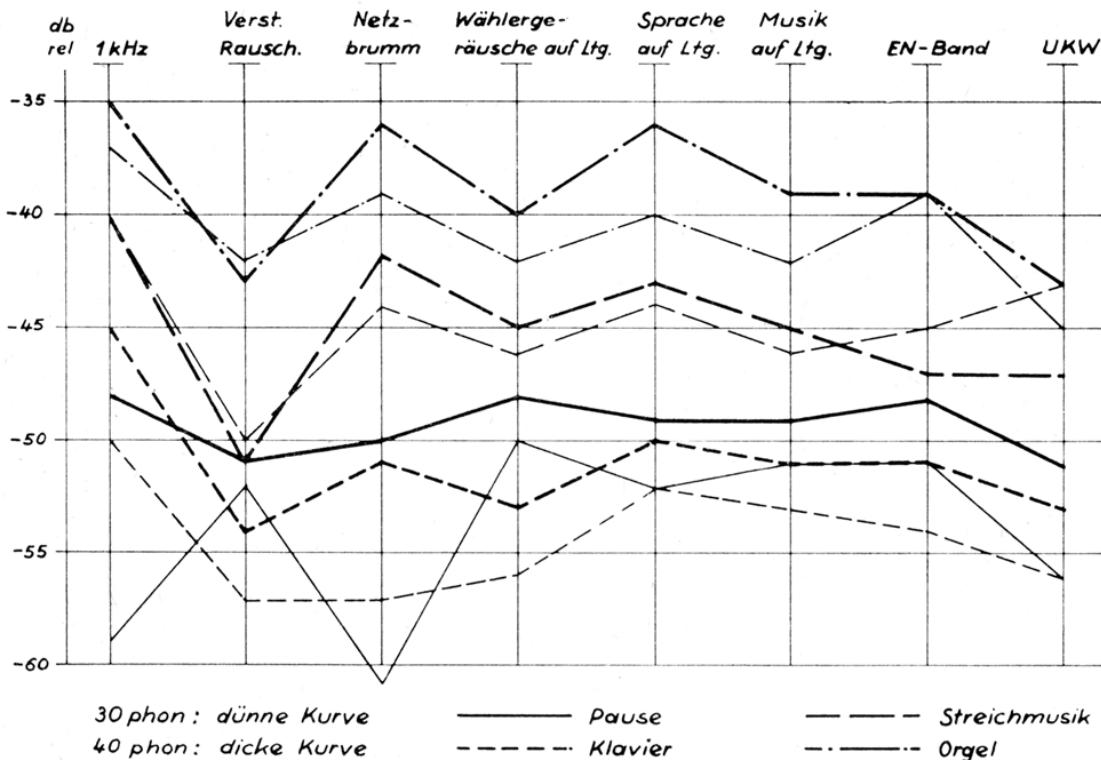


Bild 10. Von den Versuchspersonen geforderter Geräuschspannungsabstand für verschiedene Nutz- und Störmodulationen bei Raumgeräuschpegeln von 30 und 40 phon. (0 db = Vollaussteuerung).
— Pause ... Klavier — · — Orgel — — — Streichinstrumente

**Fig. 10. Noise voltage ratio required by test subjects for various useful and disturbing noises at room levels 30 and 40 phon. (0 dB = full modulation).
Pause ... Klavier - . - Orgel - - - Streichinstrumente Fig. 5. Required damping response for interrupted sine wave, room level 30 phon.
— Pause ... piano - . - organ - - - strings**

Explanations/translations for Abb10-13 /fig.10-13:

1kHz sine wave.

Verst Rausch = Verstärker Rauschen = amplifier noise floor, hiss.

Netzbrumm = mains hum.

Wählergeräusch auf Ltg.(Leitung)= relais contact noise on the line.

Sprache auf Ltg (Leitung) = speech on the line.

Musik auf Ltg.(Leitung) = music on the line.

EN-Band = Eisen Normal-Band = FeO² recording tape, normal thickness.

UKW= UltraKurzWelle = VHF FM-radio band.

Gesamtmittel = overall average / mean value.

Mit Bewertungskurve nach ZT = weighting curve after ZT applied (central technology group).

Effektivwert mit CCIF 1949 = RMS with CCIF weighting

Fig. 10 shows the averages of the noise margin demanded by twelve test subjects.

First the large differences, which were determined depending upon the program material, interference and room sound level, were a surprise.

Thereby obviously the program material has the by far largest influence. That is all the more remarkable, than the program selections differ not at all so much from each other; in all cases it concerns high-quality and relatively quiet, transparent music.

Pauses and piano music again prove as the most critical cases. The more transparent string music used here is however – contrary to the first recording – more sensitive to disturbance than the organ music. The differences in level correspond what was to be expected after the measurements for the psophometer curve. All interferences lie substantially in the middle frequency range, in which particularly in calm rooms the evaluation curves for the individual kinds of music diverge strongly. Thus for example a mean of 13 dB results for the difference between piano and organ music from both test series.

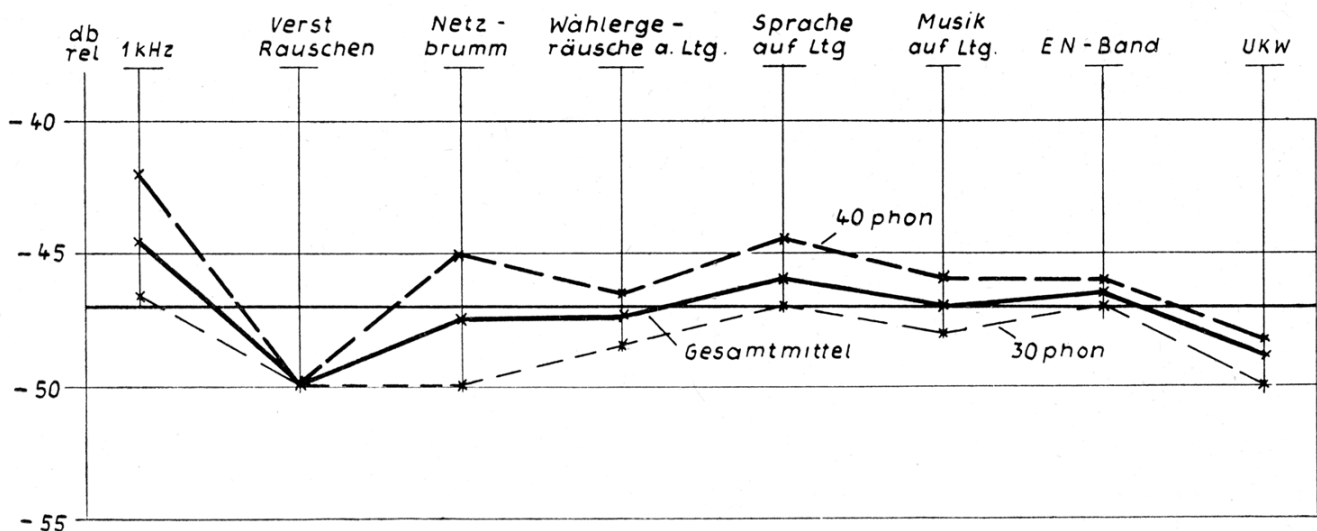


Bild 11. Mittelwert über die Nutzmodulationsarten nach Bild 10

Fig. 11. Average over the useful signals of Fig. 10

Pauses and piano music again prove as the most critical cases. The more transparent string music used here is however – contrary to the first recording – more sensitive to disturbance than the organ music. The differences in level correspond what was to be expected after the measurements for the psophometer curve. All interferences lie substantially in the middle frequency range, in which particularly in calm rooms the evaluation curves for the individual kinds of music diverge strongly. Thus for example a mean of 13 dB results for the difference between piano and organ music from both test series.

The ambient room level brings a total shift generally only around 2 to 3 dB.

The values for different interferences within a series of measurements are rather constant, thus the evaluation by the J 77 follows the subjective breakdown impression well.

Remarkable are the high requirements for attenuation of the steady tones (1000 Hz and power line hum) along with missing modulation (break) in calm rooms. In presence of program material, in particular with organ and string music, these tones are very little disturbing. This probably corresponds with the experience that such tones are easily masked by changing program content, despite being audible, because that obviously attracts the attention of the listener more.

The average values in [Fig. 11](#) indicate more clearly the good agreement of the measured values of the J77 with the subjective evaluations.

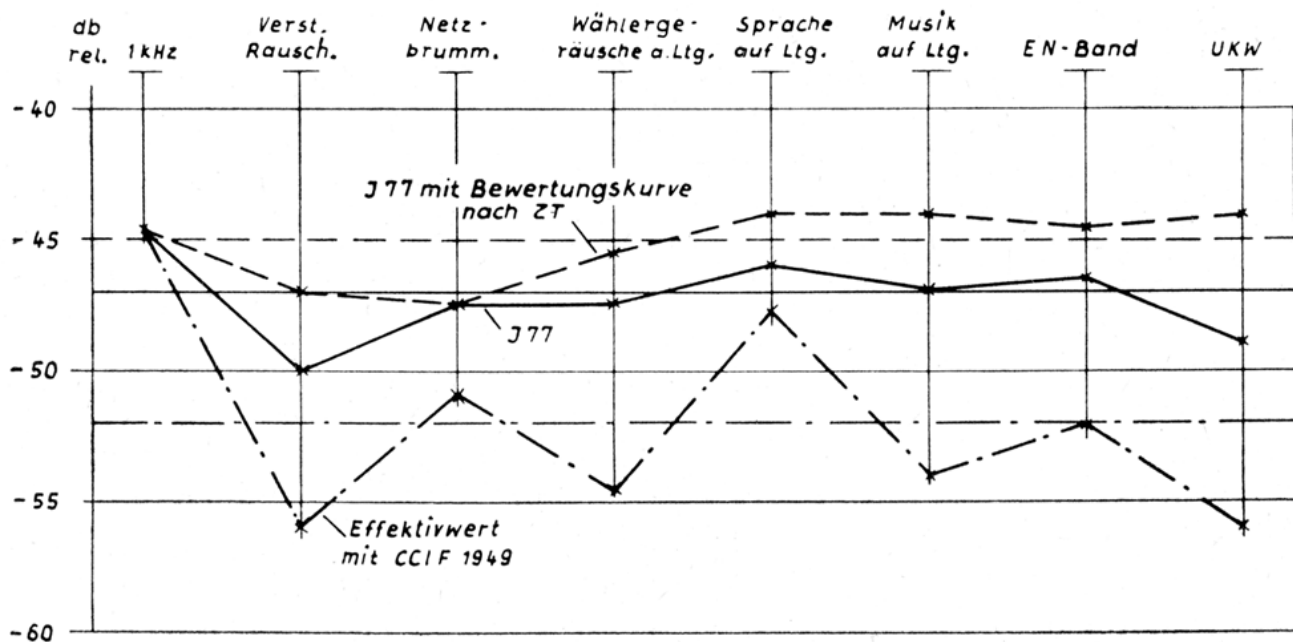


Bild 12. Vergleich der Anzeigewerte eines J 77 (Störbewertungskurve CCIF 1949) mit denen eines J 77 mit Bewertung nach dem Vorschlag der ZT sowie mit den Werten eines Effektivwertsinstruments (Störbewertung nach CCIF 1949)

Fig. 12. Comparison of readings from J77 (weighting CCIF 1949), J77(weighting ZT), and RMS meter (weighting CCIF 1949)

The use of the suggested new weighting curve [ZT: “Zentraltechnik” (central technology group)] brings a further adjustment to the horizontal ([fig. 12](#)), thus certain improvement, if one wants to draw such conclusions from the available material, which is to serve predominantly different purposes. (Mean error 0.75dB instead of 0.9 dB, mean error from subjective evaluation 0.65 dB.) There are substantial errors with the RMS measurement, with up to 8 dB deviations from the average value (mean error 2.3 dB). Also this test clearly indicates the superiority of the peak detector.

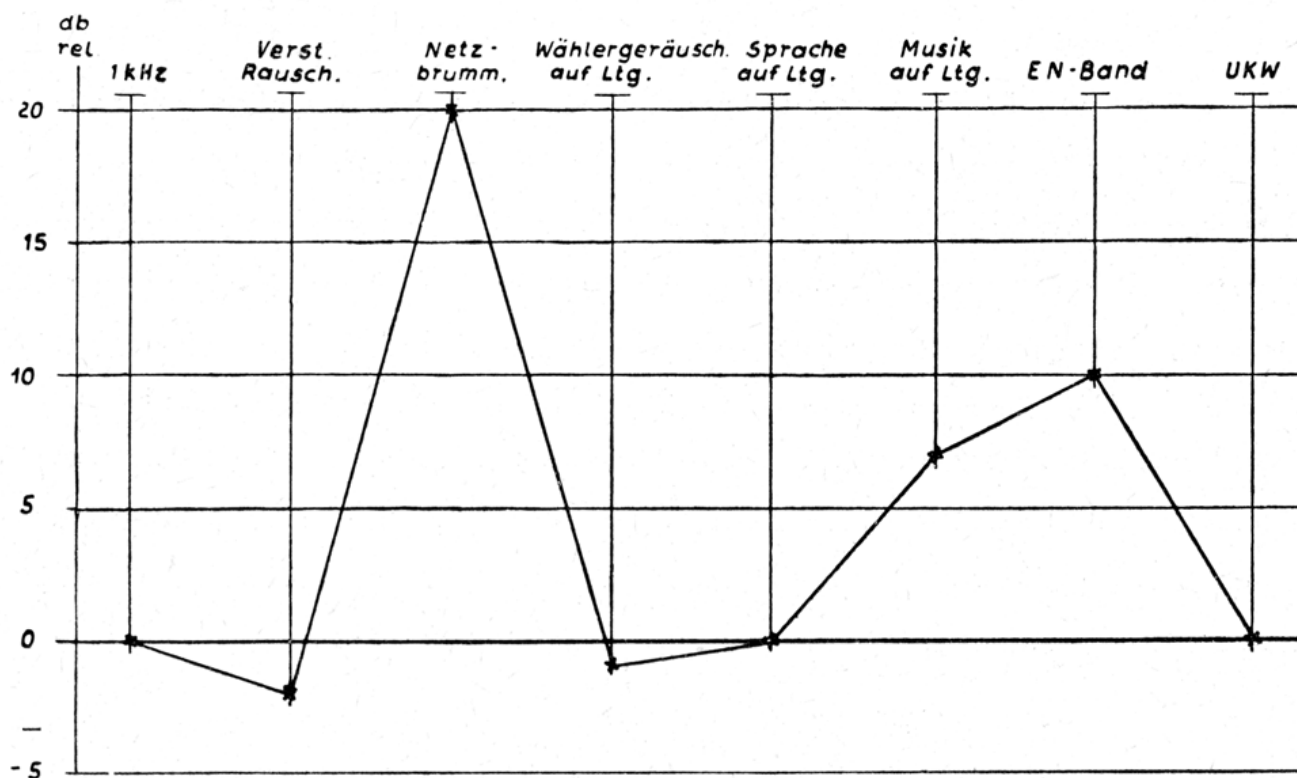


Bild 13. Vergleich der Fremdspannungswerte von Geräuschen, die gleiche Geräuschspannungspegel besitzen

Fig. 13. Comparison of unweighted levels vs noises with equal weighted levels

Fig. 13 shows the unweighted levels of noises, after the weighted noise had been adjusted for 0 dB reading, both voltages measured with J 77. Both with amplifier noise floor and with relays contact noises the weighted levels appear higher than unweighted.

Conclusions from part 2

It's in the nature of quality requirement that significant value must be granted to personal opinion – not least, because the implementation is often connected with a substantial economic expenditure.

In the case under consideration it concerns above all, which program material is to be used for the test, and whether the listener with normal demands is to be the judge, or one with high requirements. Furthermore – and this is probably the most difficult aspect – the mental attitude of the test persons must be considered, its influence must be numerically estimated. This aspect is far more important here than the definition of the psophometer curve for the disturbance, because it cannot be questioned that such an influence is present, but it is by no means certain that it appears more or less pronounced through the frequency bands.

If we take the most critical program as a basis for the evaluation according to our principles, with piano music in a quiet listening room we get an average at 54 dB.

The group of fastidious music listeners required several dB higher signal-to-noise ratio. This derives from the fact that such test subjects adjust to a substantially higher playback volume than the average listener. Since due to the nonlinear connection between loudness and sound pressure the disturbing modulation is disproportionately strongly raised thereby, that leads to higher requirements for reduction of noise at the same time.

On the other hand we may however accept that the test subject, who expects a disturbing noise in order to be able to judge, will be substantially more critical than the usual listener, who normally concentrates his attention on the program. In this context the afore-mentioned fact becomes interesting, that the first disturbing noise is evaluated with 4dB more tolerance than the following disturbances.

Apparently the test subject is initially closer to the natural attitude and becomes more critical only later after an assessment is required. An interpretation in the sense that the listener becomes more sensitive with the duration of the disturbances is less probable, since the character of the disturbance constantly changes. Also this would contradict the everyday experience that power line hum or a noise at the beginning of a transmission commonly disturbs, while later in the program it is often ignored completely.

In consideration of all of these circumstances one can conclude that a weighted signal-to-noise ratio of 55 dB (measured by peak-voltage meter type J77) is to be sought. Beyond that no further increase is to be represented, if it is connected with considerable costs.

A margin of 45 dB might cause no impairment with most types of program material still cause no impairment, and even with 35 dB large parts of the program are still audible with satisfying quality.

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