Some Quality and Coverage Problems in Audio Broadcasting

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Introduction

When we are planning broadcasting coverage in an area, we normally begin by examining the transmission conditions. The available bandwidths are given in international agreements, and we also refer to the other parameters given there. However, are there other conditions that may influence the strength and the quality of the received signal?

In order to simplify the considerations, we have in Figure 1 indicated how the coverage may be from a transmitting station placed in an area with homogeneous conditions in all directions. The coverage is here divided into three areas: the near coverage area, an intermediate coverage area, and a distant coverage area. Is it possible that we may have contradictory interests between these areas concerning broadcasting quality and broadcasting coverage?

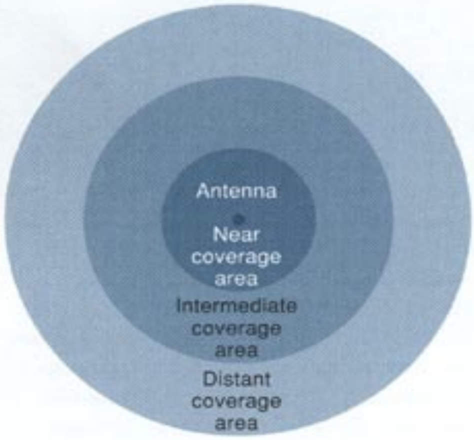


Figure 1 Coverage when the transmission conditions are the same in all directions

Special Conditions in AM Broadcasting

In 1975 there were some modulation tests at the Oslo AM transmitter station. At that time the frequency was 218 kHz and the radiated power was 200 kW e.m.r.p. (effective monopole radiated power). These tests were carried out by a group consisting of members of the Norwegian Broadcasting Corporation and the Norwegian Telecommunications Administration.

The reason for performing the tests was that there were complaints concerning the audibility of the transmissions. One of the plaintiffs said: We hear the carrier but not the modulation.

The first investigations showed that the mean modulation for the Oslo AM transmitter was only about 30 %. It was proposed to use a *limiter* (see Figure 2) for the modulating signal. This would cause a reduction in the dynamic range, but at the same time the mean modulation would increase causing an increase in the sideband power and thereby better audibility. *As long as the carrier is not severely overmodulated, it is*

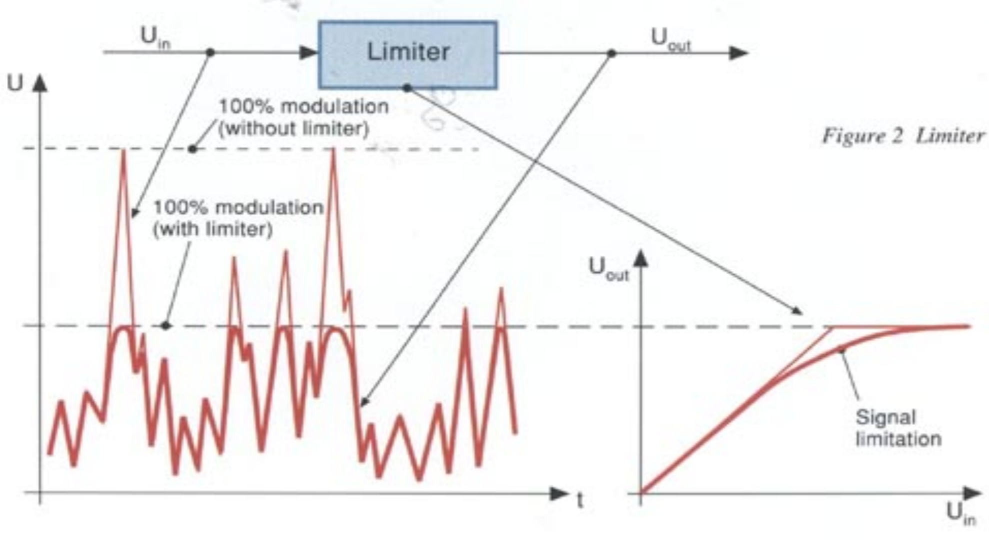


Figure 2 Limiter

the sideband power which determines the demodulated signal strength and consequently the audibility.

It should also be mentioned here that more advanced limiters are used today. For instance some of them have the possibility to limit the different frequencies independently.

There were some reluctance concerning the use of limiters, just due to the reduction in the dynamic range of the signal. It was therefore decided to use relatively moderate limitation. However, the mean modulation was raised from about 30 % to about 70 %; that is, the sideband power was increased by 6 – 7 dB, and the test should then compare the receiving conditions with and without limiter at the transmitter.

Because we wanted professional people to judge those tests, the Radio Interference Division in the Norwegian Telecommunications Administration was engaged to listen to the transmissions. In addition they had people at different locations in the coverage area of the Oslo AM transmitting station. In order to avoid biased judgements they were given as few details as possible. They were told to use field strength measuring equipment, a normal AM receiver, and a variable attenuator to judge any subjective variations. They were also instructed to describe as exactly as possible all that happened to the AM signal at the changes.

The time interval for the changes between transmission with and without limiter was 2 minutes. In order to avoid any doubt about the time for changes, the clocks were synchronised.

The tests were done in the daytime, that is, it was mostly the ground-wave which was investigated. Then it is the natural electromagnetic noise which limits the signal-to-noise ratio. However, the use of a limiter would be even more advantageous for transmission via the ionosphere where interference normally determines the audibility.

We got some unexpected results. Most of the listeners said that the dynamics of the signal seemed to increase when the signal (that is, the sideband signal) strength increased. In fact, we then reduced the dynamic range of the signal. We had to give this result some thought before we got into the explanation of the problems, and the answer is that we have to consider the coverage range for the signal and the quality of the signal.

If we look at a field strength curve, for example the thick solid curve in Figure 3, this curve is *a mean curve*, that is, a curve measured with a slow instrument. If we had an instrument that could follow the modulation, this instrument would swing between the absolute values of the modulation as also indicated in Figure 3. These peak values are relatively the same for different distances. We may here observe that we need not move so far away from the transmitting station before a rather large part of the dynamic range is coming into the noise, and this part of the dynamic range is of no use.

If we now increase the transmitter power by 6 – 7 dB, the mean curve will increase with the same value, for instance to the thick dashed line in Figure 3. We then observe that at the same time more of the dynamic range is over the noise level, giving more usable dynamics to the listeners.

It does not matter whether the increase in the radiated power is due to the increase of transmitter power or to the increase in sideband power, on the assumption that we have no severe overmodulation.

Another unexpected result was the subjective assessment of the increase in the signal strength. Most of the listeners thought that the increase in signal strength was about 6 – 7 dB, but in about 130 km from the Oslo AM transmitter the observers thought that the increase was as high as 10 – 15 dB. Because several observers at about the same distance had the same impression, it was necessary to find the reason for this phenomenon.

The AM group organised these investigations. We began measuring near the transmitting station and were a bit surprised that the 6 – 7 dB could be observed subjectively also near the

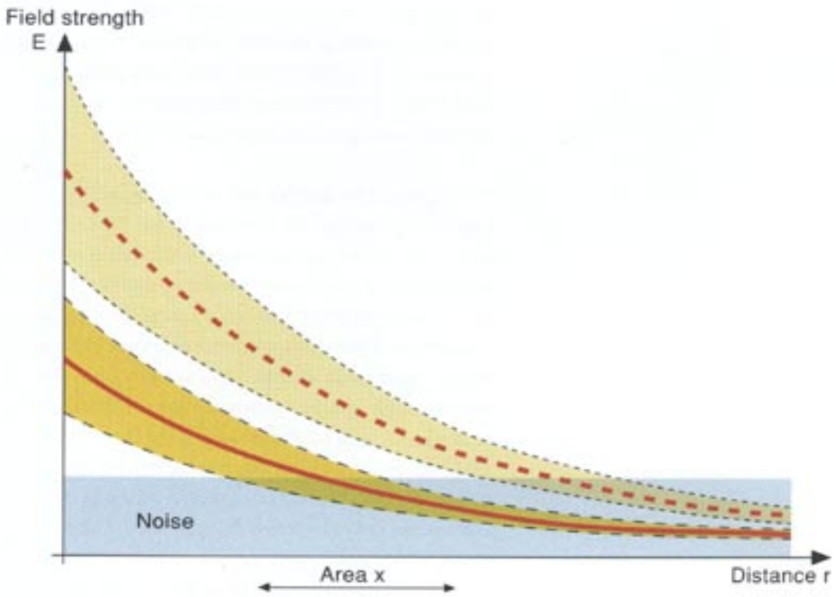


Figure 3 Field strength curves

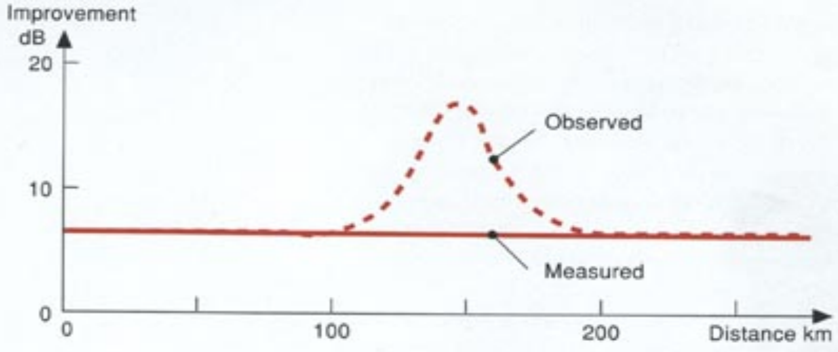


Figure 4 Subjective and objective measurements

station. We had not expected 6 – 7 dB to have any noticeable effect in the large field strengths near the transmitter. An explanation may be that the noise in this frequency band is higher than indicated in Figure 3.

The improvement both for subjective and objective measurements was about 6 – 7 dB until we were about 100 km from Oslo. Then the observed signal strength seemed to increase from the earlier 6 – 7 dB, and in some areas at about 150 km we observed more than 18 dB. This large difference between subjective and objective measurements may be explained by the fact that in this area (area x in Figure 3) the signal was increased so much that the signal-to-noise ratio was changed from not usable to usable.

Several other conditions influence the audibility of an AM broadcasting station. Because of small modulating signal bandwidth (4.5 kHz to the –3 dB point for broadcasting in the long and medium waves, and 5 kHz to the –3 dB point in the short-wave band) the form of the amplitude curve for the modulating signal is of great importance. Without shaping, that is, with linear amplitude curve for the modulating signal, we get too much bass and too little treble. Using a moderate shaping which here means extra amplification of the highest modulating frequencies, will give a better balance between bass and treble and consequently better audibility.

With respect to quality and coverage, we will here have conflicting interests. *If we look at Figure 1, only the near coverage area will have full advantage of high quality transmissions.* Further away from the transmitting antenna, in the intermediate and the distant coverage areas, the signal-to-noise ratio will be reduced to values too low for high quality transmissions. Here we have to decide which of the areas are the most important for the transmissions. It may not be appropriate to go for very high quality which is of advantage only for listeners near the transmitting station. It may be more advantageous to reduce the quality requirements in order to give the intermediate and the distant coverage areas a reasonable signal strength and quality.

There should be a certain liberty to choose between quality and coverage, and this must be discussed when planning the transmissions. However, it should be pointed out that when a broadcaster will go for high quality transmissions, the values must not be so extreme that it will lead to unacceptable use of the frequency resources. It will then be a matter for the frequency regulation authorities.

High quality transmissions in low frequency, medium frequency, and high frequency broadcasting, is possible by using digital coding and compression. If we at the same time introduce stereo, there will be very little difference between such transmissions and high quality FM transmissions, especially when listening in cars.

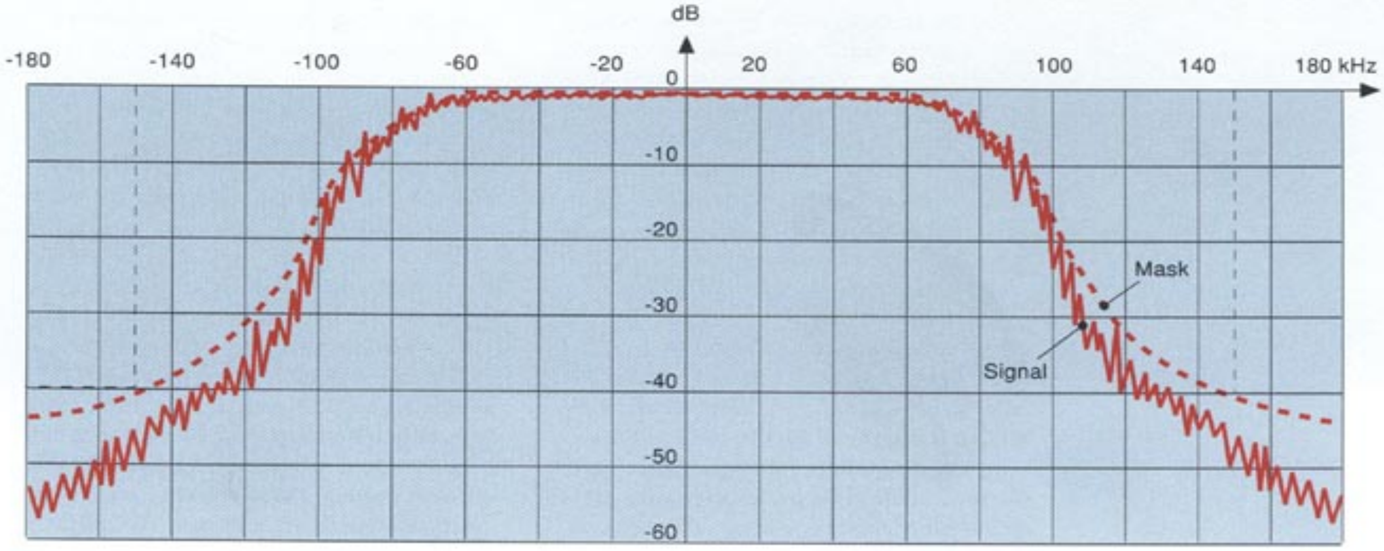
Special Conditions in FM Broadcasting

In FM broadcasting we have about the same problems as for AM concerning coverage range and received signal quality. However, because FM is a relatively complicated modulation system, it is rather difficult to get a clear view of the modulating process.

For instance the signal from an FM transmitter is dependent on both the amplitude and the frequency of the modulating signal. Therefore it is difficult to measure the deviation with a simple instrument, for example a deviation measuring equipment. We may have good results when such an instrument is used directly at the FM transmitter, but if we have other signals near the measured channel, a deviation measuring equipment will also take these signals into account. In principle a deviation measuring equipment has to be rather broad-banded because it shall measure frequency deviation.

The measurements of the deviation of the FM sound signal in a television signal (with 50 kHz deviation) have normally been done with a deviation measuring equipment. However, it is then possible that we may get the luminance signal, the colour signal, the NICAM signal, etc. into our measurements. This may be the reason why many television transmitters have rather low deviation for FM sound signal. It is here more suitable to use a spectrum analyser to see the real deviation. A limiter for the sound signal may also be advantageous, not only for the modulation, but also because we get less interference to the colour and the luminance signals.

In Figure 5 is shown the frequency envelope curve for a well modulated FM broadcasting transmitter (with 75 kHz deviation). A limiting



curve, a mask, is also given, and the signal curve should be kept within these limits. However, it is not so easy to consider the envelope curve for such an integrated signal. As mentioned before, the deviation is dependent on both amplitude and frequency for the modulating signal, and there will often be a discussion if the mean value of the signal or the peak values should be used. If we go for the latter, we have to be aware of the fact that the results will very much depend on the accuracy of the instruments.

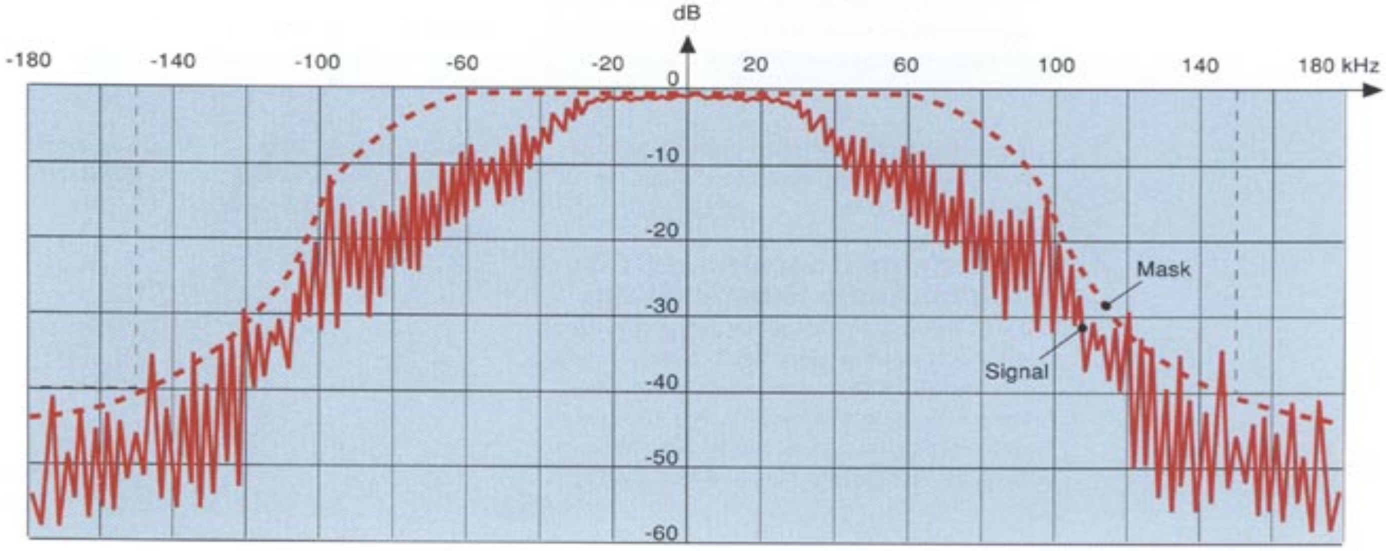
It is not of great importance for the signal strength or for the interference conditions if the signal exceeds the mask within the actual channel. The most important is that the specified values are fulfilled in the adjacent channels giving low interference to other transmissions. This necessitates a limiter in the modulating signal. *This limiter begins to influence the signal at ± 100 kHz, that is, outside the necessary bandwidth for the FM signal, 180 kHz.*

Even a small limitation will give a rather large increase in audibility. Therefore it may be more favourable to use a little limitation in the modulating signal instead of increasing the bandwidth some kHz.

In Figure 6 is shown how the signal may be from an FM transmitter without limiter (free dynamic conditions). We see here that the usable deviation has to be very much reduced in order to keep the signal within acceptable limits. In this example the usable deviation is only about 30 kHz. *And because the FM demodulators in the receivers give a received signal strength which is directly proportional to the deviation, the audibility will be extensively reduced in comparison to the use of limiter.*

Figure 5 Mask and envelope curve for a well modulated FM broadcasting transmitter

Figure 6 Mask and signal curve for an FM transmitter without dynamic limitation



These circumstances may lead to odd results. A well modulated small FM transmitter may be heard with a larger signal strength in the receivers than a high power FM transmitter with low modulation level, provided that the field strength is sufficient to give acceptable reception. In one case an FM transmitter with 10 W effective radiated power (e.r.p.) gave better audibility than an FM transmitter with low modulation level but 100 kW e.r.p.

If we want all the FM transmitters to be received with about the same audio level in the receivers, all of them should have the same deviation conditions. But again we have to consider the audibility and the quality of the signal. If we want to sacrifice a little of the quality in order to get better audibility, this is possible on the condition that the signal is kept within given limits.

If we want to increase the quality of an FM signal by reducing the deviation, we will get poor utilisation of the channel. Looking at Figure 1, it is only the near coverage area that will be an advantage of such transmissions. The intermediate area and the distant area will get lower signal quality because of too low signal-to-noise ratio. It is again necessary to consider quality and range of the signal.

In most European countries it has been agreed that the necessary bandwidth of an FM broadcasting transmitter is (Carson's formula):

$$B = 2(d + f_m) = 2(75 \text{ kHz} + 15 \text{ kHz}) = 180 \text{ kHz}$$

where B is the necessary bandwidth, the deviation parameter d is 75 kHz (in the rest of Europe 50 kHz), and the highest transmitted modulation frequency is $f_m = 15$ kHz. This means that we take an extra component outside the deviation parameter 75 kHz into account. To consider higher components in the FM signal will give very little influence on the signal quality. These components are relatively small, and in addition the signal-to-noise ratio for these components will be very low.

It may be mentioned that for planning purposes an FM broadcasting channel bandwidth was agreed to be 300 kHz.

Comments Concerning DAB (Digital Audio Broadcasting)

If we want to have high quality audio broadcasting, digital audio broadcasting is a possible solution. Up to now there is no other new system which may compete with DAB. It is also easy to regenerate digital signals, and we have full quality for the received signal until the field strength is so low that the transmission is interrupted. And because the retarded signals or reflections are used in a positive way, the reception of DAB in mountainous and hilly terrain is totally superior to the reception of FM broadcasting. This is especially observed in mobile reception. In flat terrain without reflecting objects the difference is rather small.

It may also be mentioned that when it was agreed to introduce DAB, this should be done within the already existing frequency band, 87.5 MHz to 108 MHz. Some countries had already begun to allocate frequencies for DAB in that band. However, the BBC in Britain had done some tests and measurements for DAB in different frequency bands, and had come to the conclusion that frequencies in the 100 MHz band were not especially advantageous for DAB. The results were better at higher frequencies, and it was necessary to find a higher frequency band that could be allocated to DAB. *TV channel 12, 223 MHz – 230 MHz, and the band 230 MHz – 240 MHz seemed to fulfil the requirements.*

Conclusion

When planning and operating audio broadcasting, it is important to consider very carefully the quality and the coverage range of the signal. A reasonable balance between them will give a good utilisation of the frequency resources.

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