

The Case Against Low-Frequency Pre-Emphasis in Magnetic Recording*

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Data on low-frequency energy distribution in music do not justify the use of low-frequency pre-emphasis, and subjective low-frequency noise does not require it. Therefore the elimination of low-frequency pre-emphasis is suggested. Practical implications are also discussed.

THE low-frequency response characteristic used for professional magnetic sound recording has received relatively little attention. We would like in this paper to examine the presently used low-frequency pre-emphasis: What is it, and why is it used? Are there any compelling reasons why it should or should not continue to be used?

The low-frequency ($1-f$) pre-emphasis used in the United States is that recommended by the NAB Standards.¹ This is shown in Fig. 1: a 6 db/octave rise, with a transition frequency (+3 db point) at 50 cps. Note that most professional recording equipment is specified to 30 cps against the NAB Standard, but the NAB Standard ends at 50 cps! Present practice is generally to assume the extension of this 6/db octave slope, as shown by the dashed line, more or less to the lower limit of the audio range, giving a boost of 5 db at 30 cps, and an ultimate boost of 8 db at 20 cps.

The energy distribution in speech, and in instrumental and orchestral music certainly *does* justify using this pre-emphasis; Fig. 2 shows representative spectral analyses of an orchestral and a popular music recording²—little energy is seen below 50 cps.

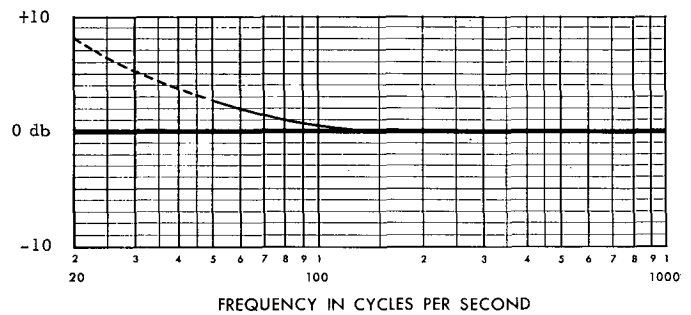


FIG. 1. NAB Standard low-frequency pre-emphasis characteristic for magnetic recording.

The benefit to be gained by the pre-emphasis is that the complementary de-emphasis gives a reduction in low-frequency noise to the extent of 2 db at 60 cps (the power-line hum frequency) and 5 db at 30 cps. This 2 db hum reduction is rather insignificant, and the very low-frequency noise is seldom a problem.

So far, then, the pre-emphasis seems to do little real good, but neither does it appear to do any harm.

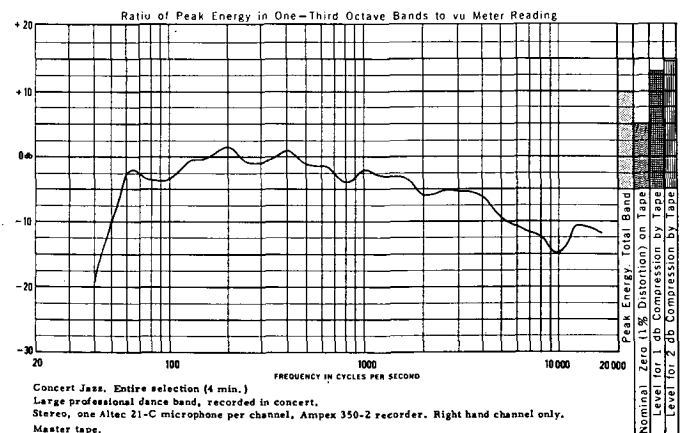
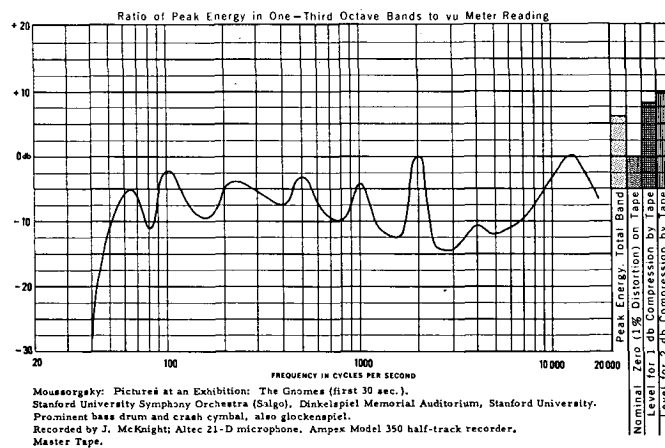


FIG. 2. Representative spectrum analysis of recorded music: left, orchestral; right, popular.

* Presented April 4, 1961 at the Eighth Annual Spring Convention of the Audio Engineering Society, Los Angeles.

¹ NARTB Recording and Reproducing Standards, Sec. 2, Magnetic Recording (June, 1953).

² J. G. McKnight, *J. Audio Eng. Soc.* 7, 65-71, 80 (1959).

But how about that "hi-fi" fan's delight, the pipe organ? Figure 3 shows that the energy here lies mainly in the low-frequency region—it rises continuously from the higher frequencies to the lower ones;² this continues at least to 35 cps, which was the lowest filter on our spectrum analyzer. It is

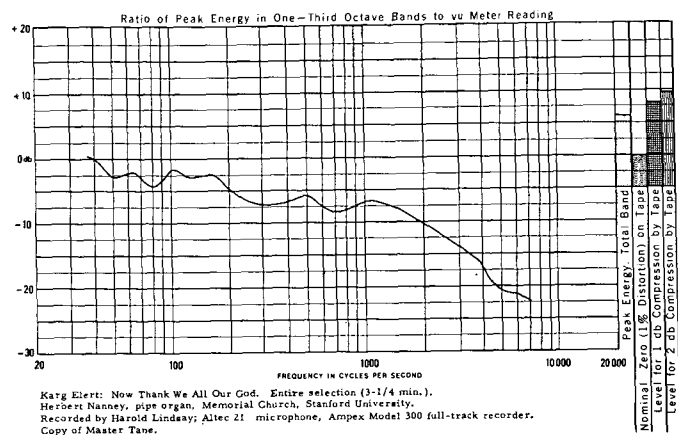


FIG. 3. Representative spectrum analysis of recorded music: pipe organ.

probable that the lowest frequencies determine the vu meter reading; but at 35 cps the pre-emphasis is about 5 db, so that the low-frequency level on the tape would often be some 5 db higher than the engineer had really intended, causing increased intermodulation distortion. We see that the organ, which is the only instrument with appreciable low-frequency energy content, is done a considerable disservice by the pre-emphasis.

In the case of remote and concert recording sessions, we should also consider such minor calamities as the rumblings of ventilator fans, the "bang" of a door accidentally slammed, or (in New York) the rumble of the ubiquitous subway. Any of these might cause low-frequency intermodulation problems which would be aggravated by the pre-emphasis.

We should also note that the flat low-frequency characteristic (*i.e.*, no pre-emphasis) is presently used in Europe (the CCIR Standard³), with apparently good results and acceptance.

Here, then, we have seen several reasons why low-frequency pre-emphasis should *not* be used. The manufacturer of magnetic recorders gains a small advantage, too, in the elimination of a precision R-C pre-emphasis network.

What problems would we introduce by eliminating this pre-emphasis? As far as the NAB Standard itself is concerned, no problem would exist, as the NAB tolerance is -5 db at 50 cps, and unspecified below 50 cps. One could eliminate the pre-emphasis entirely and still fall within the tolerance.

Snow⁴ has shown that the complete elimination of all frequencies below 60 cps is scarcely noticeable in instrumental

³ CCIR, Recommendation No. 135, Standards of Sound Recording for the International Exchange of Programmes, single track recording on magnetic tape. *Documents of the VIIIth Plenary Assembly* 1, 170-183 (London, 1953).

⁴ W. B. Snow, *J. Acoust. Soc. Am.* 3, 155-166 (1931).

and orchestral music, even under the most critical conditions. Therefore the droop introduced in playing recordings made with no pre-emphasis on a reproducer equalized for pre-emphasis would generally go unnoticed.

Although we might have difficulty in finding anyone who would admit it, it is not uncommon practice in transferring tapes to disc masters to use a 70 cps high-pass filter, except for organ recordings. It is generally found that the elimination of these very low frequencies gives an improvement in overall sound quality, since the low frequency noises are eliminated, and (as Snow has shown) no significant musical content is removed. Here, of course, any difference in *equalization* below 70 cps is completely eliminated.

If a tape recorded *with* pre-emphasis were reproduced on equipment designed to be flat without pre-emphasis, an undesirable low-frequency boost would result; Fig. 4 shows the

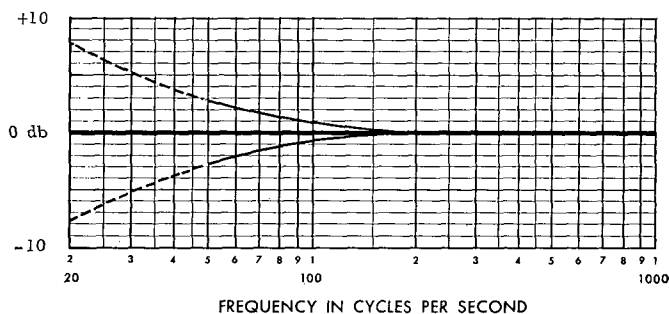


FIG. 4. Maximum frequency response error from recording with or without low frequency pre-emphasis, and reproducing with or without low frequency de-emphasis.

errors which could possibly result from the various combinations of recording, with or without pre-emphasis, with reproducing, with or without de-emphasis. (In practice, many of the multi-channel mastering recorders have had a reproduce frequency response rising to the upper limit of the tolerance at the low frequencies, so that the deletion of the pre-emphasis would bring the overall response nearer to flat, and little change would be required in the reproduce equalizer.)

The indication, then, is that for the reproduction of the past library of tapes, the difference in response would not generally be serious. If this response difference were felt to be of real consequence, compensating equalization could be added at the tape duplicator mastering stage, or at the disc mastering stage.

The advantages to be gained by the *elimination* of the pre-emphasis, and the establishment instead of a "flat" low-frequency recording characteristic, would be primarily that of reduced low-frequency intermodulation distortion for recordings of organ or of sources which have large amounts of low-frequency noise; this is done without sacrifice of the overall subjective noise level. Secondary advantages would be the slight simplification in the recording equalization network, and the establishment of a simply achieved *standard* response down to the very low frequency end of the audio spectrum.

Comments on this subject would be welcomed by the author.