Cassette equalization: the standard view

With audio as a world wide business, the interchangeability of cassettes is ever more vital

By Ed Foster

Considering the number of years cassettes have been around, it might be surprising to hear that cassette equalization is not as straightforward a proposition as meets the eye. It would be easy to explain the confusion on an East-vs.-West basis, in that the cassette was originally a European development (invented by Philips of the Netherlands). But that would be a rather simplistic view; Japanese manufacturers do not all agree with each other, much less with the Europeans. One might also point out that the cassette was originally envisioned as a dictation means, and for that purpose, standardization of equalization is less important than in its present use as a high-fidelity music medium. But, again, that explanation is weak, for seldom has any company ruled its licensees more thoroughly than has Philips in such things as tape speed, track width and location, and the physical characteristics of the cassette itself. In the final analysis, it is not important *why* there are differences but only that the differences exist.

Alphabet standards

There are many organizations whose purpose it is to standardize either methods of measurement or performance (or both), or to establish means by which compatibility among equipment is ensured. Most major countries have national standards organizations, such as ANSI in this country, DIN in Germany, and the CCIR in France. Then there are manufacturers' organizations and engineering institutes that promulgate standards — the IEEE and EIA (into which the old IHF has been merged) in the U.S., and the EIAJ in Japan. Last, but certainly not least, there is the IEC — the International Electrotechnical Committee — which has representatives from both Western and Communist countries and seeks to establish *international* norms. Considering the world-wide popularity of the cassette recorder, it would appear that this is the organization to turn to at least insofar as interchangeability of software is concerned.

The establishment of an equalization standard is simply a means of insuring interchangeability of cassettes. As long as a cassette is recorded and reproduced on the same machine, it really makes no difference which equalization is used. For that matter, track width, track placement, and azimuth need only be standardized so that a tape recorded on one machine can be played properly on another. But in order to insure interchangeability of software, the reproducer must have heads whose track width, placement, and azimuth angle match those of the deck on which the tape was recorded. Similarly, to reproduce the tape with the correct frequency response, the playback equalization must complement the recording equalization so that, together, they compensate for recording and playback losses.

What are those losses? Ignoring the loss due to azimuth misalignment (which, at least theoretically, shouldn't occur if both record and playback heads are properly aligned), the main playback losses are caused by the finite length of the play head gap, the unavoidable separation between the tape and the play head poletips, the magnetic losses in the play head core, and whatever electrical losses might occur in the interface between the inductive head winding and the preamplifier. There are two other play head peculiarities: the so-called "contour effect" produced by the finite pole-piece length used in the play head (and resulting in "head bumps" or irregularities in low-frequency response); and the 6dB/octave rising response (for constant flux level on tape) that is characteristic of all rate-of-change-of-flux-sensitive devices such as the normal playback head.

On the recording side of the ledger, there are core losses and separation losses too. The size and shape of the gap also plays a role in establishing how deeply into the magnetic coating the tape is recorded and how sharply defined the "critical recording zone" is. In conjunction with the tape formulation itself and the choice of bias level, these determine the relative strength of short-wavelength (high-frequency) information compared with long-wavelength (low-frequency) information.

Record or playback equalization?

Insofar as the playback losses are, in the main, caused by imperfections in the playback head and its interface with the playback electronics, it would seem logical that compensation for these losses should take place in the

playback electronics and the losses should not be "pre-compensated" for in the recording equalization. Similarly, it would seem sensible to correct for *recording* losses in the recording equalization so that, despite imperfections in the recording head, each recorder produces as theoretically perfect a recording as is possible. In this way, a designer could choose whatever bias field he deemed most appropriate and use whatever recording preemphasis is required to create a "proper" response with a theoretically perfect playback system. Only in this way is true tape interchangeability assured; every recorder would assume that the tape would be reproduced on an ideal playback system, and every playback system would assume it was reproducing a theoretically ideal recording.

Of course, there has to be some *generalized* equalization implied. Here is where the curves come in: the so-called "120-microsecond" (for Type-I — ferric) and "70-microsecond" (for Types II, III, and IV — chrome, ferrichrome, and metal respectively). The purpose of these curves (and the 3180-microsecond low-frequency break now standard for *all* tapes) is to make a "first cut" at correcting for the 6dB/octave rising response of the typical playback head, the energy distribution of music, and the basic high-frequency losses common to all recording systems.

The nut of the question is whether these "standard playback equalizations" apply to the playback *electronics* or to the playback *system*. That is, should one simply dial these fixed equalization parameters into the playback electronics and then juggle the recording equalization to compensate for other playback losses, or should one instead use the "standard playback equalizations" as a *starting* point and modify them for the playback losses peculiar to that deck? It would seem sensible to adopt the latter approach, and, indeed, a careful reading of the IEC standard (Publication 94 is the one that applies) would imply that this is the "correct" technique.

The first amendment to IEC Publication 94 defines the "short-circuit flux" of a magnetic tape as "The flux which flows through the core of a reproducing head which has a zero reluctance (read, no core losses) and is in intimate contact with the surface of the tape (read, no spacing loss) over an infinite length (read, no contour effect)." It then goes on to specify the *recorded tape flux characteristic* in terms of the *short-circuit tape flux versus frequency* as the result of the combination of two curves, i.e. the 3180 and 120 (or 70) microsecond curves that we have always used. Clearly, this seems to indicate that the playback system is assumed to be "ideal," and that playback losses should be compensated for in the playback electronics so that the "real" system is as close to ideal as is feasible.

Pre-equalized test-tapes

I may seem to be belaboring the obvious, but the point seems to have escaped most designers. More often than not, cassette decks are engineered *without* correction for playback losses in the playback equalizer, which simply contains the composite of the two curves (3180 and 70 or 120 microseconds). All additional losses are corrected in the *recording* equalization. Nakamichi, the one company that, practically from time immemorial, has compensated for playback losses in the playback equalizer, has frequently been accused of "non-standard equalization" when, in fact, its approach seems to be in precise adherence to IEC standards.

This peculiar state of affairs is attributable, in large measure, to the propensity of test tape manufacturers to pre-equalize their frequency response tapes for a presumed playback gap length and spacing loss. Insofar as the losses in a playback head match the presumption on which the test tape was created, it will appear to yield flat response *without* additional correction. A deck that has correction for playback loss built into the playback equalizer — and thus, *as a system*, appears ideal — will exhibit a rising high-end when tested with a tape whose high-end has been boosted to "correct" for presumed playback losses.

This idea of generating a test tape based upon the presumption of certain playback losses is not a new one; it goes back to the early days of open reel. At that time, Ampex was probably the leading tape deck manufacturer and, for internal use, created a frequency response test tape. Early Ampex recorders used a playback head with a 250 microinch gap, and its test tape was designed to compensate for that playback gap. Ampex then was induced to sell these tapes.

Everything went swimmingly until Ampex adopted narrower playback gaps (100 microinches) in order to extend the bandwidth of the deck. Tested with the old tape, the new decks had a rising high-end. Little by little, the test tapes were deemphasized to show flat response on the newer and better players.

The NAB standard, which was in general acceptance at that time, was written in terms of a *playback* equalization rather than a recorded flux characteristic, and that, in a sense, blessed a rather questionable practice. For that matter, there may be some cassette standards extant today that follow the same philosophy. My only point is that IEC Publication 94 does not seem to be one of them, and that, both from the point of view of its international recognition and from the point of view of common sense, it seems to be the one to follow. Recent indications are that tape deck manufacturers other than Nakamichi also seem to be adopting this posture, and are compensating for playback losses in the playback equalizer. Common sense and good engineering practice may yet win out. **AVI**