X-Curve Is Not An EQ Curve

By Michael Karagosian

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A commonly misunderstood tool in cinema sound is the X-Curve. The very name suggests it has something to do with equalization of the sound track. In fact, it has nothing to do with soundfield equalization. Far from it, X-Curve describes a measurement method designed to allow the setup of a cinema sound system to match the sound heard by the director in the mixing room.

To understand X-Curve measurements, it's important to understand the challenges of equalizing cinemas. The most prominent mechanisms that influence the sound of an auditorium are the loudspeaker characteristics, room reverberation, acoustical reflections in the room, and the absorption of sound by air. The primary tool by which we attempt to overcome the audible artifacts introduced by these mechanisms is the equalizer. Unfortunately, even a finely adjustable equalizer is not a match to the complex acoustical anomalies that can occur. But some correction is possible, and it is that which we pursue.

Good sound begins with good loudspeaker systems, but even the finest loudspeaker system will be compromised when placed behind a perforated cinema screen. Perforated screens introduce diffraction patterns and other interference that varies from installation to installation, requiring equalization to mitigate. A technique for reducing the impact of room reverberation and reflection in measurements is to measure in the vicinity of the loudspeaker, often called "near-field" measurements. But this technique is not without problems in the cinema. Multi-way loudspeakers require that the measurement microphone be placed some distance from the speaker system to capture the full frequency response, and the loudspeakers are mounted high behind a screen, which itself is mounted some distance above the floor. This is not a casual measurement to make when one has a 13m-high screen.

When placing the microphone further back in the room at a more convenient location, sound absorption, room reflections, and room reverberation come into play. Sound absorption is not a simple matter, attenuating frequencies around 10KHz by as much as 5 dB at 30 m, depending on temperature and atmospheric conditions. Room reflections are generally unwanted and caused by architectural features of the auditorium. In part, it is the problem of unwanted reflections that led to the multiple microphone technique commonly used with X-Curve. Notably, neither reflections nor absorption should be addressed with equalization. Reflections should be dealt with using acoustical treatments, while absorption is a factor that the technician must take into account during the measurement. Room reverberation is a feature of the acoustics of the room, perhaps imparting the biggest impact on the room's "tone." Reverberation is another factor that will influence the sound of the room. Reverberation imparts a frequency characteristic to the room, but it remains a temporal phenomenon, which makes it difficult to correct using frequency-domain equalization. Notably, the impact of reverberation on surround sound will be far less than its impact on the sound of screen speakers.

The problem of room equalization, therefore, generally reduces to the correction of the acoustic coupling of the speakers to the screen and the room. There are two classes of measurement techniques that can be applied: the first embodies a method to equalize the room, based only on first arrival sound,

while the second embodies a method that takes into account the effect of room reverberation. Thirty years ago, when attempting to devise a technique that could easily be deployed in cinemas around the world, it was decided that readily available realtime analyzers could be used if one could take into account the effect of room reverberation. Out of this thinking was born the X-Curve sound measurement method.

X-Curve is a measurement response window, based on measurements made in the reverberant environment of actual cinema auditoriums. It allows a cinema technician having off-the-shelf measurement tools to obtain a close approximation of the sound experienced in the mixing room, without the need to employ a more complex measurement method, based on first arrival sound. X-Curve generalizes the impact of room reverberation on frequency response as displayed by a realtime analyzer. SMPTE ST 202 manages this generalization by providing a range of measurement windows for use with differently sized rooms. By using the minimal equalization necessary to produce a response within the X-Curve window, the impact of room reverberation on the measurement is mitigated, and the equalization more accurately reflects that which is needed to overcome acoustical coupling problems associated with speaker, screen, and room.

While the use of X-Curve as a measurement technique has been successful in establishing a high degree of uniformity of sound in cinemas around the world, it has also received criticism. Users that do not understand the proper application of X-Curve may sometimes treat it as an equalization curve, attempting to equalize the system until an exact replication of the curve as published in ST 202 is achieved, ignoring the response window described by the text in the standard. This generally leads to excessive equalization, and not necessarily the best possible sound. In addition, the X-Curve measurement method is standardized in SMPTE ST 202 and ISO-2969, and methods for equalizing a room, based on first arrival sound are not standardized, causing temptation to discount the use of first arrival methods in cinema. But, in fact, many skilled technicians prefer to use first arrival methods, and proper use of such methods should lead to equivalent results. First arrival measurement methods tend to be based on proprietary equipment, so caution must be taken if pursuing a first arrival standard so as not to disfavor a manufacturer of valid measurement tools.

SMPTE established a new Technology Committee, TC-25CSS Cinema Sound Systems. As the name suggests, members of the committee will be evaluating other measurement methods for cinema, based on first arrival of sound. If one or more alternative cinema sound measurement standards should emerge, one should keep in mind that they are an alternative, and not a replacement, for ST 202. X-Curve, the method that takes into account room reflections, and newer methods based on first arrival of sound, both strive for the same thing: a measurement method that allows the cinema technician to best approximate the sound heard in the mixing room.

About the author

Michael Karagosian is president of MKPE Consulting, a cinema industry consultancy. He led the development of Dolby cinema products in the late 1970s and early 80s. His monthly publication mkpeReport.com provides in-depth analysis and technology coverage for digital cinema.

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