Application of Loudness in Program Production and Broadcasting (Postprint)

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Date: 2023-10-08T00:00:00+00:00

Abstract

Loudness is an important technical indicator for measuring television program quality. Different individuals perceive the loudness of audio signals differently. Therefore, in broadcast television transmission chains, the volume of all transmitted programs must be maintained at an appropriate average loudness.

Full Text

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Abstract

Loudness is a crucial technical indicator for measuring television program quality. Different listeners perceive the loudness of audio signals differently. Therefore, in broadcast television transmission chains, the volume of all programs must be maintained at an appropriate average loudness. In everyday viewing environments, program loudness must be kept at suitable levels; otherwise, noticeable loudness variations occur when switching between programs or channels, forcing users to constantly adjust volume for comfortable listening. This repetitive remote-control adjustment across programs or channels creates significant user inconvenience. Consequently, broadcast television transmission chains require all channel programs to maintain a consistent average loudness.

Keywords: Loudness; Program Production; Television Broadcasting

1. Loudness Standards

Loudness meters should be installed at non-linear editing stations and program review stations in production departments (either as external hardware or embedded software). This node serves as the final checkpoint before channel trans-

mission, where producers or reviewers verify whether loudness values are appropriate and re-edit programs that fail to meet loudness specifications.

Compared to the digital audio level unit dBFS, loudness values in LKFS units incorporate frequency weighting that better simulates how signals of different frequencies produce sensations of sound intensity on the human eardrum, enabling accurate determination of appropriate loudness ranges for audiences. The State Administration of Radio, Film, and Television (SARFT) stipulates that the average loudness range for digital television programs should be -24LKFS $±$2LU, with the maximum average loudness for any television program not exceeding -22LKFS. In accordance with these regulations, SARFT conducts real-time monitoring of program audio loudness for satellite channels to supervise broadcast quality. The specification of average loudness ranges facilitates uniform loudness production during program creation and prevents audiences from experiencing severe auditory discomfort when switching between television channels or between different programs on the same channel.

2. Loudness Units

Two loudness units are currently in use. The first is LKFS (Loudness, K-weighted, relative to Full Scale), which represents K-weighted loudness relative to digital full scale and serves as an absolute loudness measurement unit. The second is LU (Loudness Unit), a relative loudness measurement unit where 1LU is equivalent to 1dB. SARFT regulations specify that the average loudness tolerance for digital television programs should be within $±$2LU, and the average loudness value should not persist at either upper or lower edge of this tolerance range for extended periods.

3. Audio PPM Meters

The PPM (Peak Program Meter), also known as a peak level meter, is the most widely used audio meter in broadcast departments, with units in dBFS (decibels relative to full scale). PPM meters indicate signal peak levels and are therefore suitable for monitoring actual signal amplitude excursions; however, they cannot directly reflect the auditory perception of sound intensity. Consequently, a key limitation of PPM meter readings is their inability to represent perceived loudness.

According to peak level meter principles, program volume should not exceed -9dBFS, with music programs not surpassing -6dBFS. During program production, audio levels should predominantly fluctuate around a center point of -15dBFS.

4. Loudness Control Equipment

4.1 File-Based Non-Real-Time Loudness Control

Material files such as advertisements, promotional videos, TV dramas, and program segments can be sent to loudness adjustment workstations for processing. The loudness control equipment first extracts the average loudness of the entire audio file, calculates the difference from the target loudness value of -24LKFS, and applies overall gain shifting based on this difference. This adjustment generally preserves the original signal's dynamic range, thus avoiding degradation of program audio quality. Various program departments including satellite channels, advertising centers, and news centers are well-suited to this production method, with each department adding one or two loudness adjustment workstations to automatically process target program files.

4.2 Signal-Based Real-Time Loudness Control

Devices that perform real-time adjustment of audio signals are typically deployed at television broadcast terminals, making them more suitable for live programs that cannot be adjusted before transmission. Real-time loudness control equipment extracts information from portions of the audio signal and performs adjustments based on preset parameters and strategies. However, this approach typically alters the program's dynamic range, resulting in some degradation of audio quality, and the program's average output loudness may not precisely match the target value. Studio live broadcasts and television channel transmissions are appropriate applications for this method. Real-time loudness processing generally delays audio by several tens of milliseconds relative to video, requiring calibration of the relative delay between audio and video to maintain synchronization. SARFT regulations specify that the average perceptible threshold for relative timing between television audio and video is approximately +45ms and -125ms (positive values indicate audio leading video).

5. Loudness Measurement of Signals Broadcast Through Loudness Equipment

The primary parameters of loudness control equipment include control strength and response speed. Control strength represents the maximum gain or attenuation applied when loudness control is required. Response speed determines how quickly the control responds, often configured using attack time and release time settings.

6. Measurement of Our Station's Program Loudness

We conducted a ten-day loudness measurement of various programs on our Anhui Satellite TV channel, including TV dramas, advertisements, promotional videos, news, entertainment, and variety shows. Programs identified with excessive loudness included *Yue Meishi*, *Advertisement A Special*, *Xiangyue Huaxilou*,

Jiujiu Guiyi, *Eternal Love*, *Happy Photo Studio*, and *Honey Food Diary*. Programs with insufficient loudness included *Super News Field*, *Weather Forecast*, and *Health Consultation*.

For different types of satellite TV programs—such as advertisements, TV dramas, various program segments, and news—we measured the original program loudness at Point A. After processing through loudness equipment, we measured the broadcast loudness at Point B. Comparing these values revealed that for programs with minor loudness violations, the adjustment equipment could bring loudness within the normal range. However, for programs with severe loudness violations, even after loudness limiting and optimization by the equipment, loudness remained noncompliant. Therefore, these programs require loudness adjustment during production before broadcast to ensure compliance with SARFT target loudness values.

In broadcast television environments, the ITU-R BS.1770 standard provides an algorithm for measuring program loudness and true-peak audio levels, representing a methodology for loudness measurement. Our organization uses the WFM7200 oscilloscope manufactured by Tektronix to measure television program loudness. Audio loudness time-domain characteristics are shown below.

References

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Note: Figure translations are in progress. See original paper for figures.