Automatic Loudness Control in Television Broadcast:

Orban's Implementation of the CBS Loudness Meter and Loudness Controller

Automatic Loudness Control Has a Long History

- **The first automatic loudness control technology was developed by CBS Laboratories in the mid-1960s** in response to a Federal Communications Commission study regarding audience complaints about objectionably loud commercials.
- **Jones and Torick** at CBS Technology Center revisited this work in 1981 to improve loudness meter accuracy. This work was published in the SMPTE Journal.

Automatic loudness control starts with a **loudness meter** whose indications match **subjective loudness as perceived by listeners**.

Loudness Meter must take into account:

- **Loudness Addition**: For a given total sound power, the sound becomes louder as the power is spread over a larger number of *critical bands* (about 1/3-octave).
- **Frequency Dependence**: The ear's perception of loudness is strongly dependent on frequency.
- **Loudness Integration in Time**: A given amount of acoustic power sounds progressively louder until its duration exceeds about 200 milliseconds, at which point no further loudness increase is heard.

Loudness Meter Technology

- **Loudness Addition**: The meter first divides the signal into frequency bands and applies each band to a rectifier followed by a fast averaging.
- **Frequency Dependence**: The averaged outputs of the bands are summed with unequal gains that mimic the frequency-dependence of the ear.
- **Loudness Integration in Time**: The sum of the smoothed filter outputs is applied to a filter with an integration time of approximately 200 ms.

Loudness Meter Block Diagram

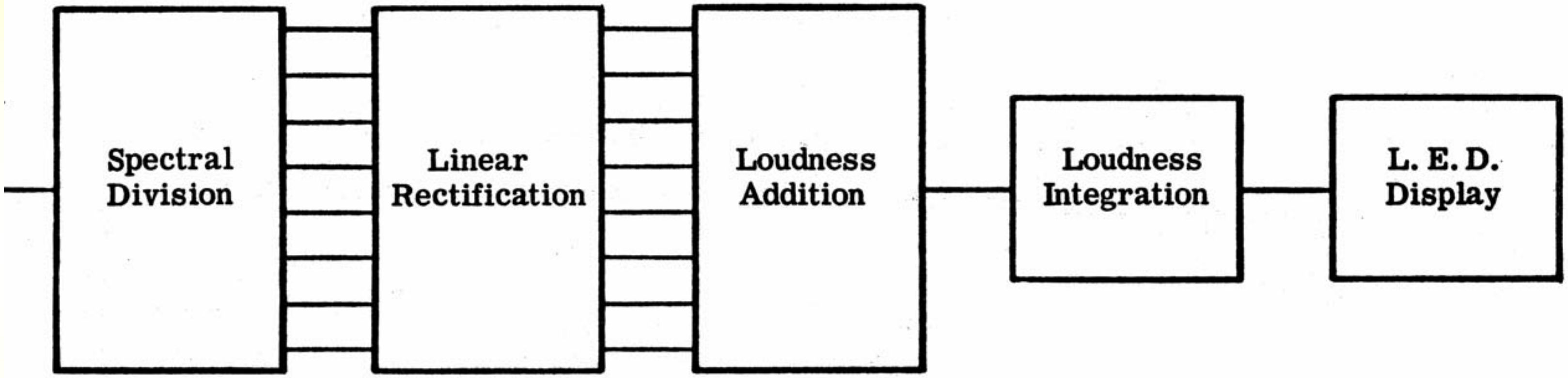
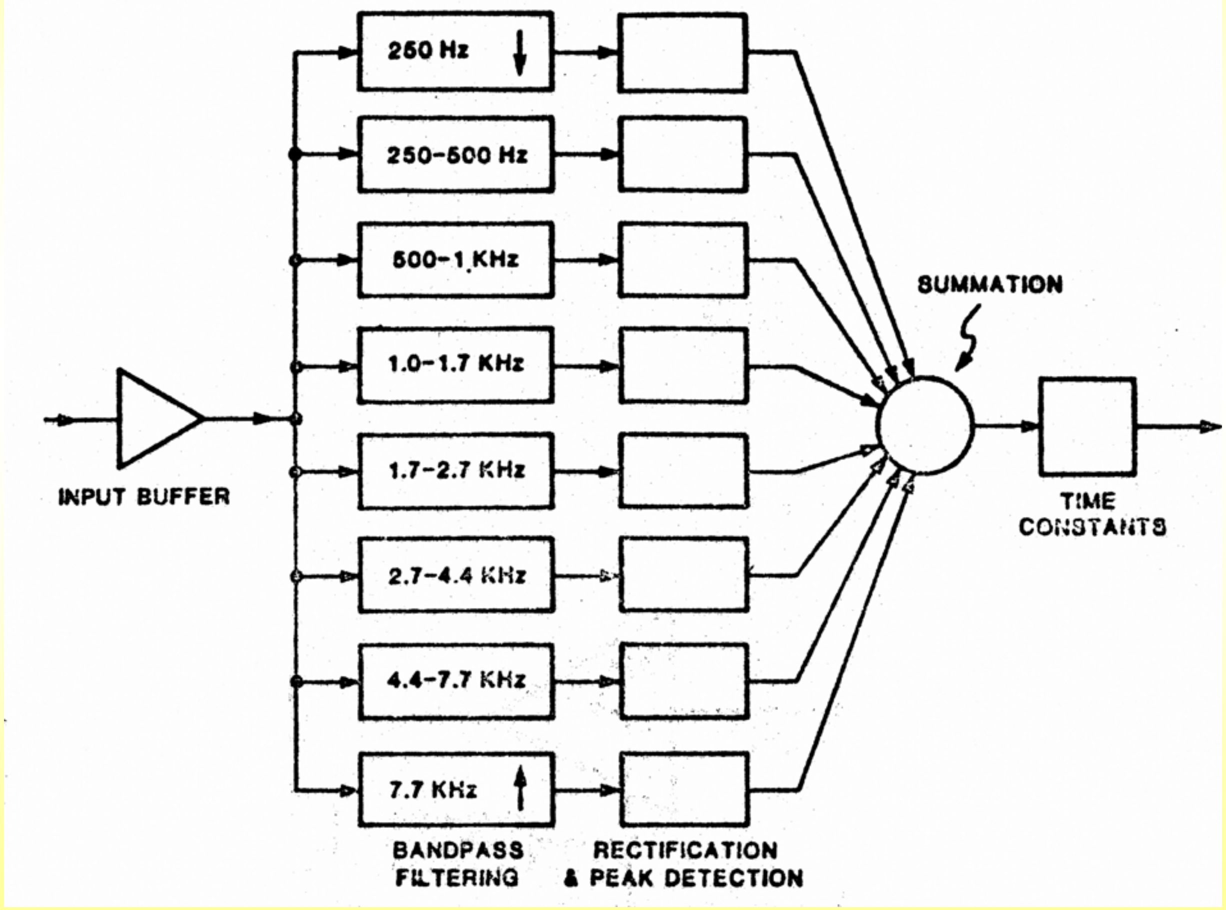


FIGURE 3. BLOCK DIAGRAM
OF CBS LOUDNESS INDICATOR

Loudness Meter Filterbank



Filterbank Curves & Summation

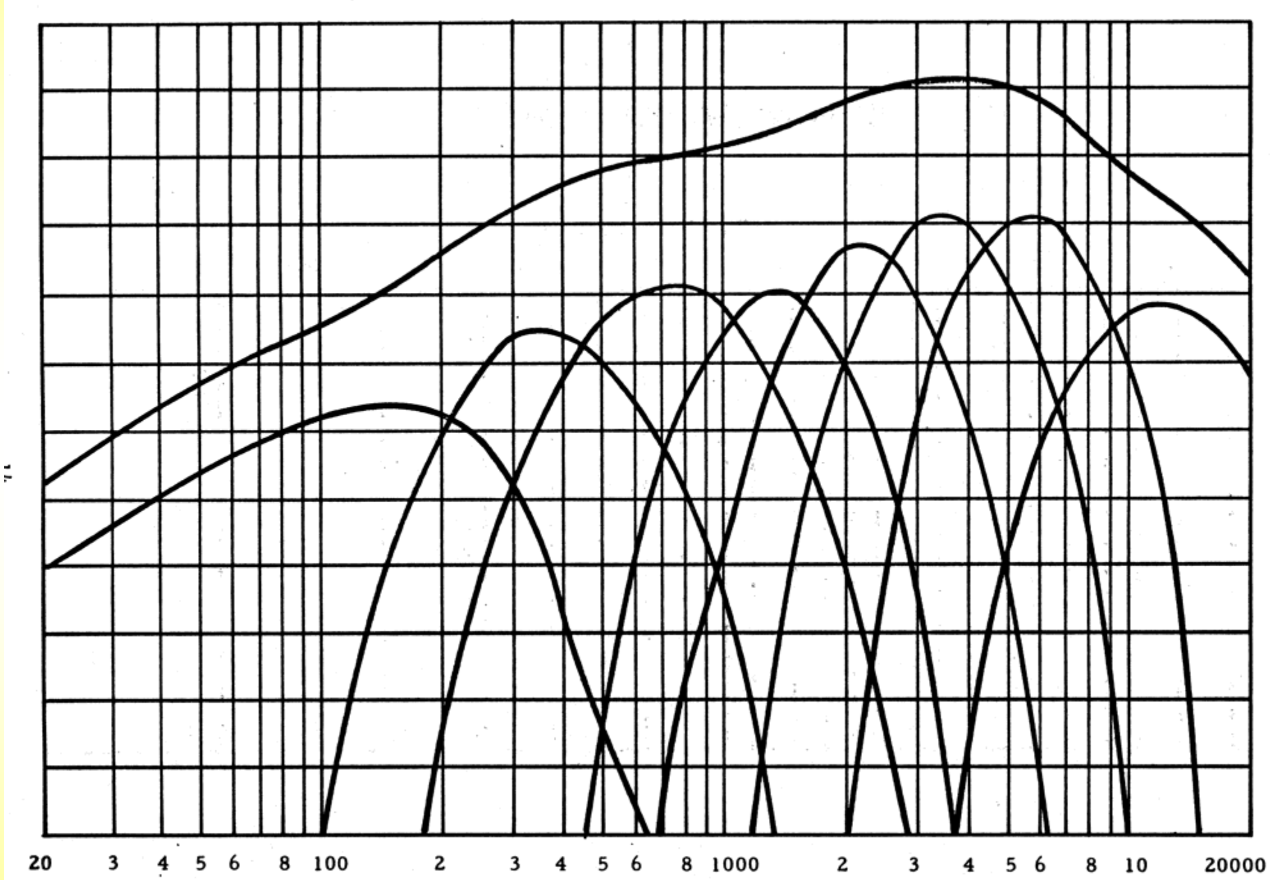


FIGURE 2. FREQUENCY IN HERTZ

Loudness Meter Accuracy Limitations 1

- Loudness meter accuracy is inherently limited by the fact that human listeners **disagree by as much as 4 dB** when asked to match the loudness of test program material with a reference tone or wideband noise. **Different people perceive loudness differently**.
- A loudness meter can only be calibrated for a **fixed acoustic listening level** because the ear's sensitivity as a function of frequency is level-dependent.

Loudness Meter Accuracy Limitations 2

- The **room acoustics** and **frequency response** of the listener's playback system are **unpredictable**.
- These issues mean that **automatic loudness measurement and control for broadcast will always be approximate**.

Comparison of Leq(RLB) and CBS Algorithms

- **Leq(RLB)** takes into account **frequency dependence** but not **loudness addition.** It **does not consider the loudness integration time constant of the ear**, so it can only measure “long-term” loudness by creating a single loudness measurement for program segments exceeding ~3 seconds in length.
- The **CBS algorithm**, by taking into account all three factors, is useful with **both speech and wideband non-speech material** and can indicate short-term, potentially annoying loudness peaks such as “esses” in speech.

Automatic Loudness Control

- To make an automatic loudness controller, one can **insert an loudness meter into a servo loop** where the loudness meter monitors the loudness controller's output and **constrains it to a preset threshold by applying gain reduction as needed**.
- The servo can be designed to produce wideband or multiband gain reduction before the loudness meter. Appropriate multiband design **minimizes audible gain pumping.**

Loudness Control in Practice

- CBS's 1981 loudness controller technology was **licensed to Orban and CRL**.
- There are **thousands of processors using this technology on-air** in television stations (mostly analog) throughout the world.
- Experience has shown that using this technology **significantly reduces listener complaints caused by loud commercials**.

Automatic Loudness Controller Program Context Limitations

- An automatic loudness controller operates with reference to an **absolute subjective loudness threshold** that does not adapt to program context as well as a human mixer.
- For example, if there is a **transition between very quiet program material** (like footfalls through rustling leaves or quiet underscoring) and a **commercial**, the commercial may still **seem offensively loud** even though the Loudness Controller is controlling its loudness correctly with reference to other sounds that reach full-scale loudness.
- While **automatic speech/non-speech discrimination** can help a loudness controller understand context, it cannot deal with all situations (like the examples above, where adjacent elements are both “non-speech”).

Loudness Measurements for This Presentation

- The **1981 CBS Loudness Indicator** was used to make the following measurements.
- The **audio processor** was an Orban **Optimod-DTV 8585**.

Loudness Measurements

- The measurements are divided into 5-second bins that contain the **highest meter indication in a given 5-second interval**.

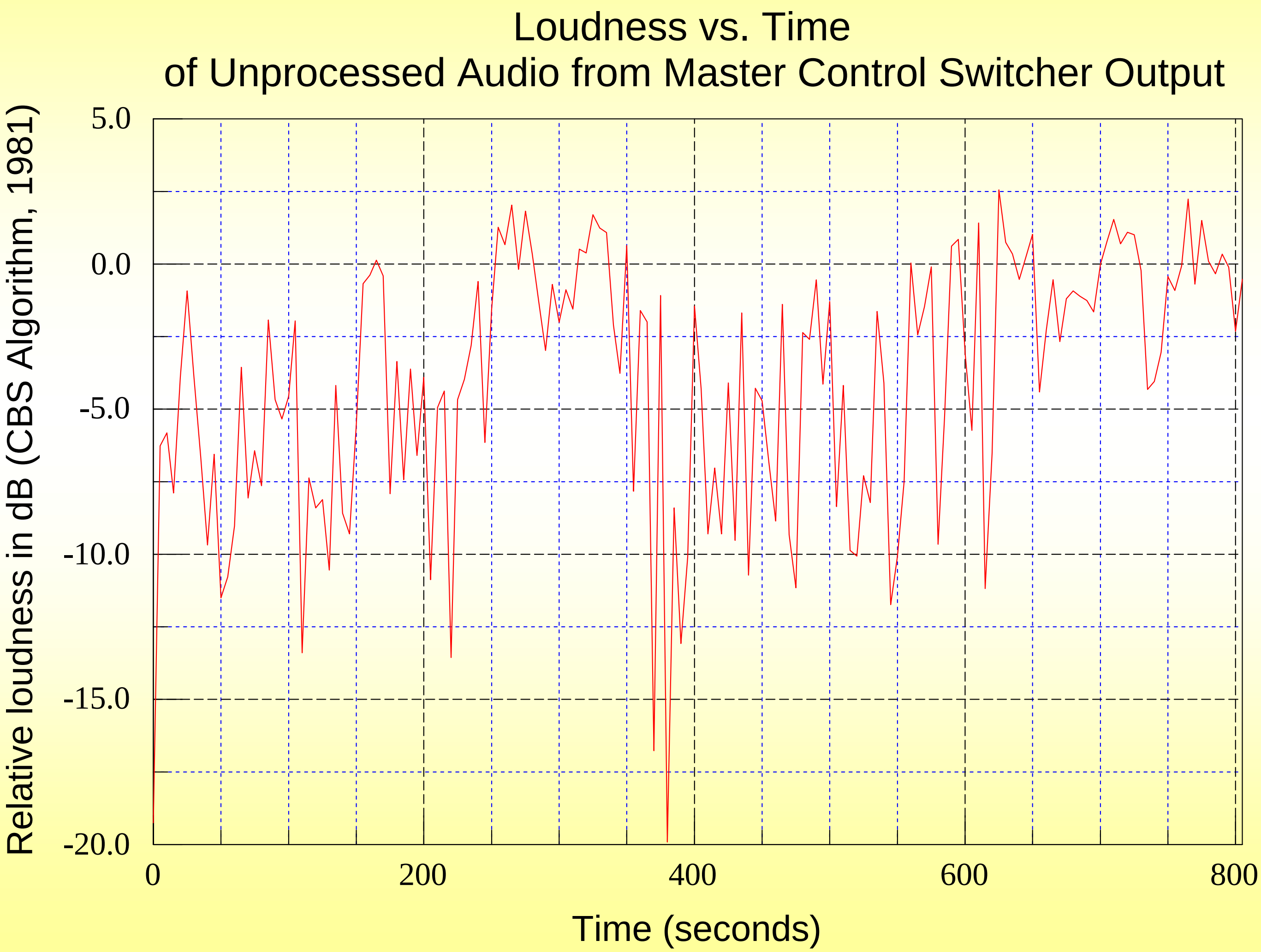
Loudness Measurements

- Program material is a 14-minute recording from the **output of a network-affiliated TV station's master control switcher**.
- The material consists of a **daytime drama** interspersed with **commercials** and **programming promotions**.

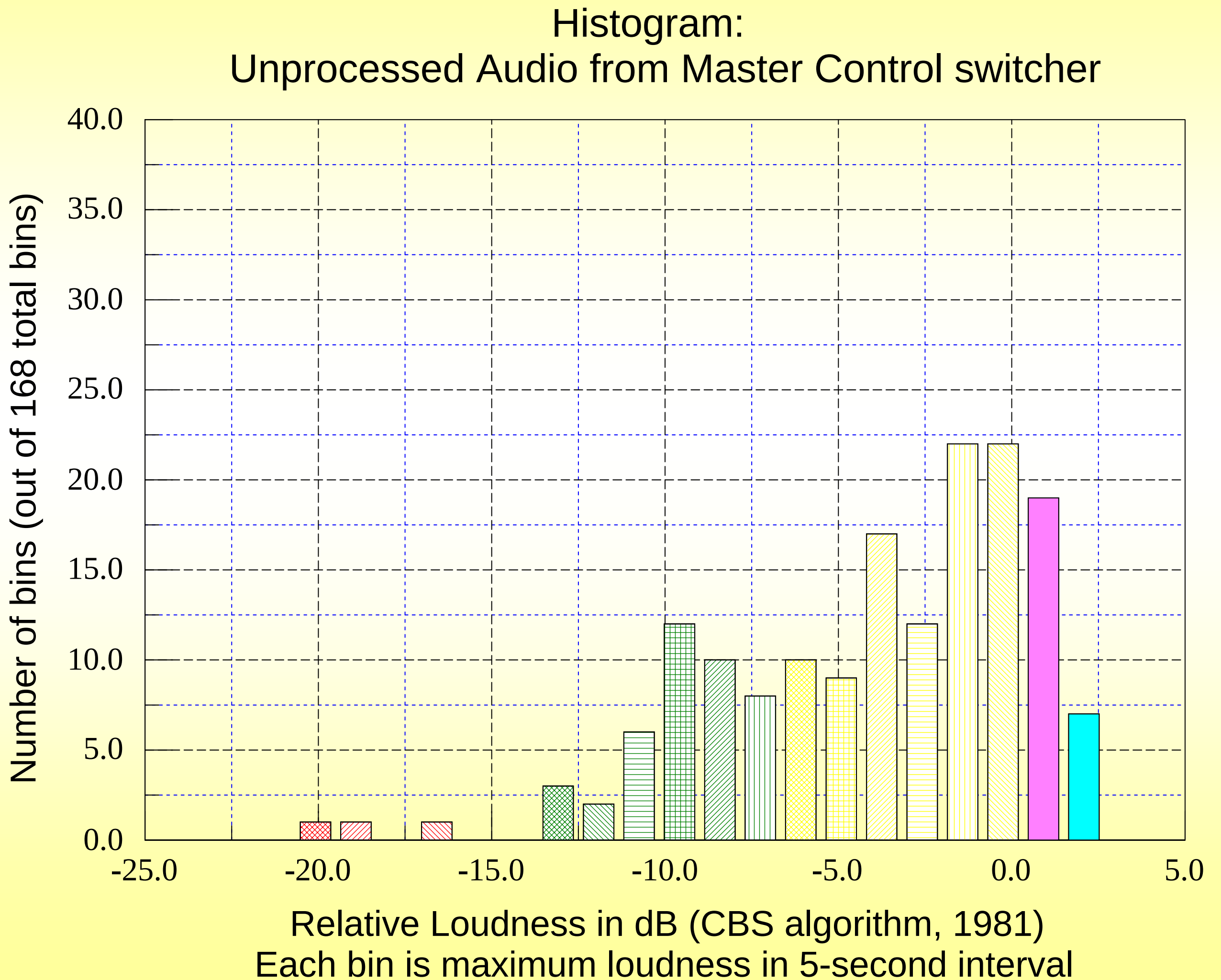
Loudness Measurements

- The following measurements show that the **loudness consistency of the unprocessed feed is not satisfactory**.
- Listening tests verify this. Program material loudness is **annoyingly inconsistent** and **commercials are much louder than the program material**. In the following chart, the commercial clusters can be easily recognized just because of their **higher and more consistent loudness**.

Unprocessed Feed



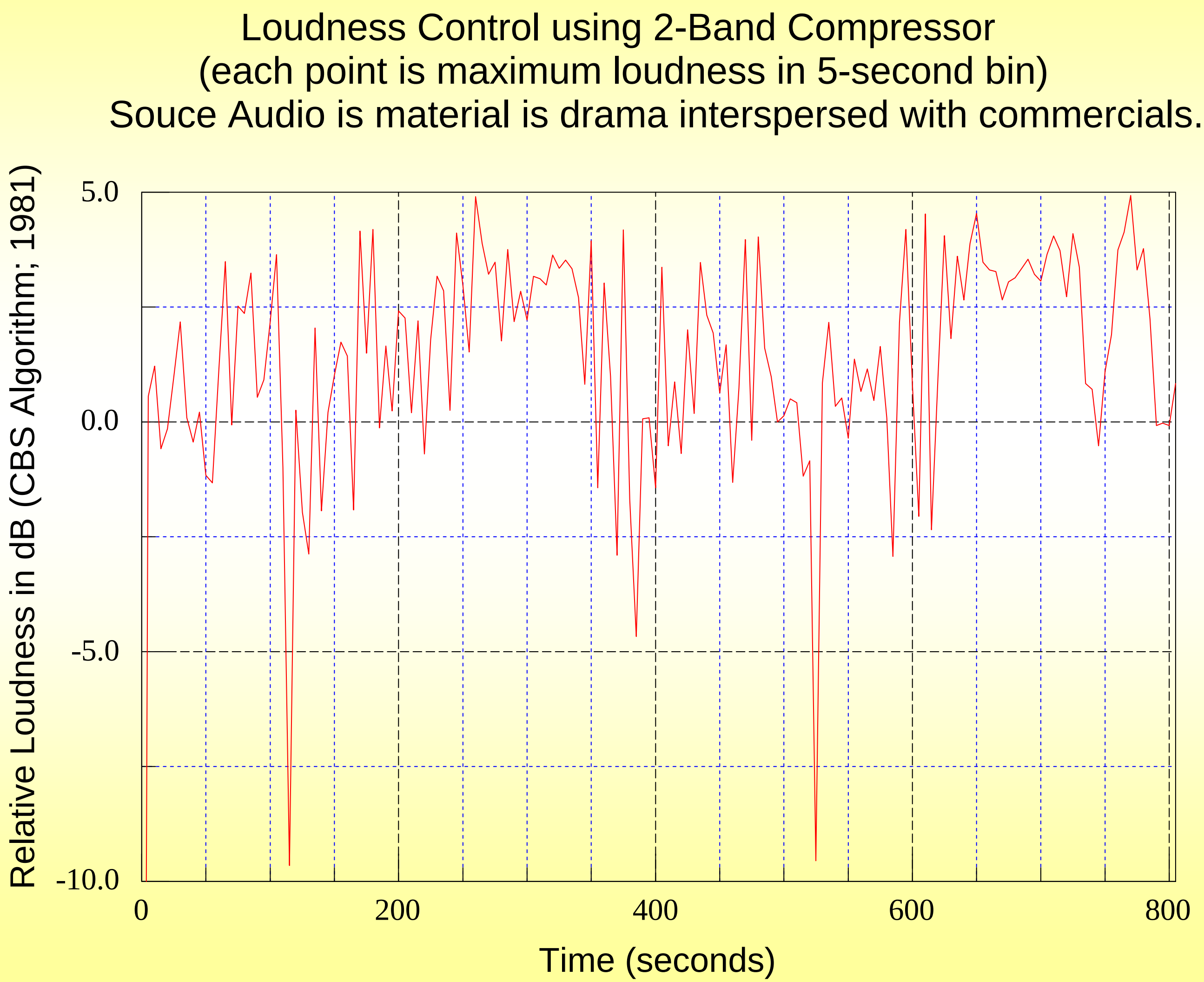
Unprocessed Feed



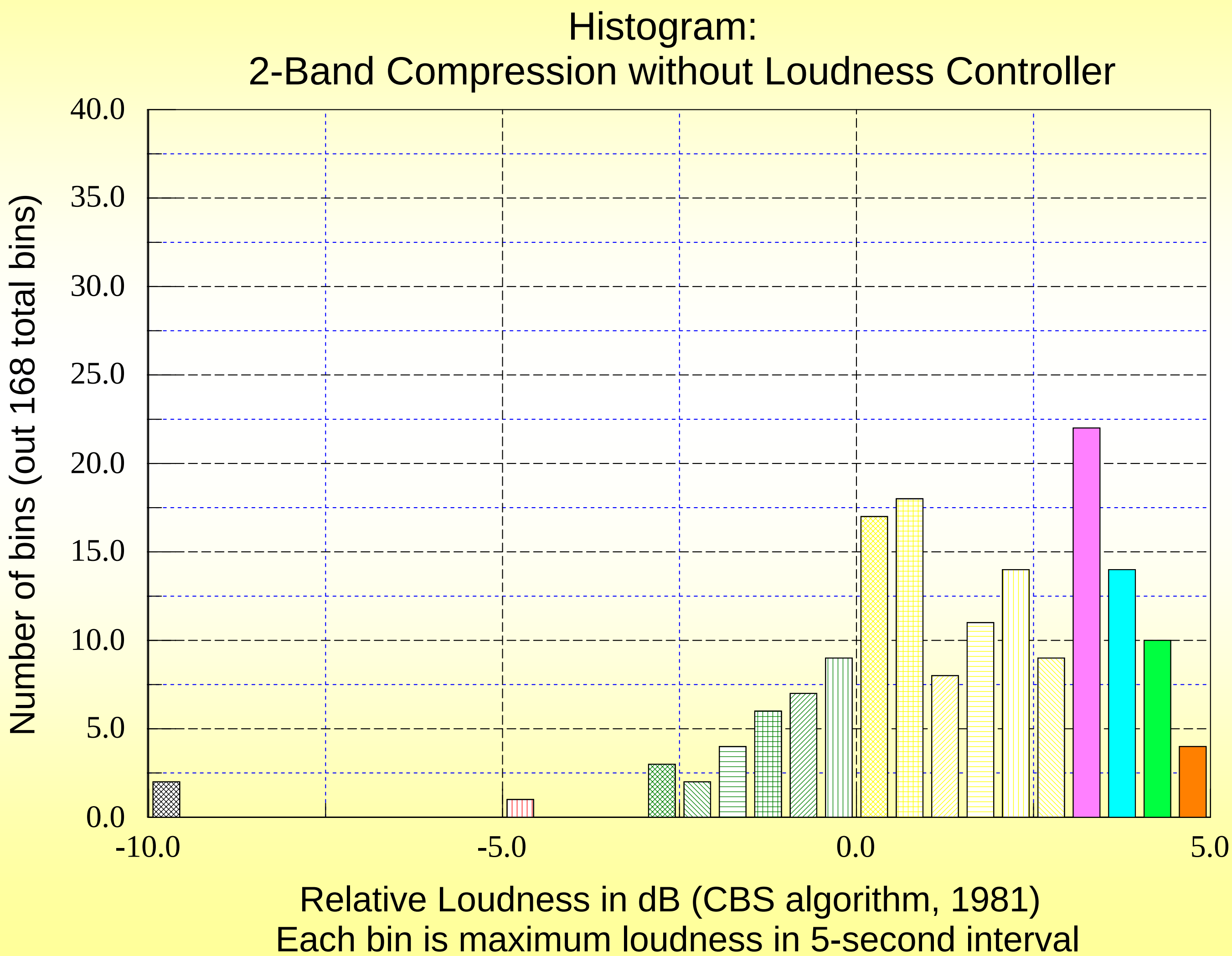
Audio Processing for Loudness Control

- The next measurements shows the loudness consistency created by **2-band compression without loudness control**. The audio processor was running its *TV 2-Band* preset.
- Consistency, while improved, is still **not good enough to prevent viewer annoyance**.
- Note that the loudness scale in the graphs has **changed compared to the unprocessed measurement**.

2-Band Compression: no LC



2-Band Compression: no LC

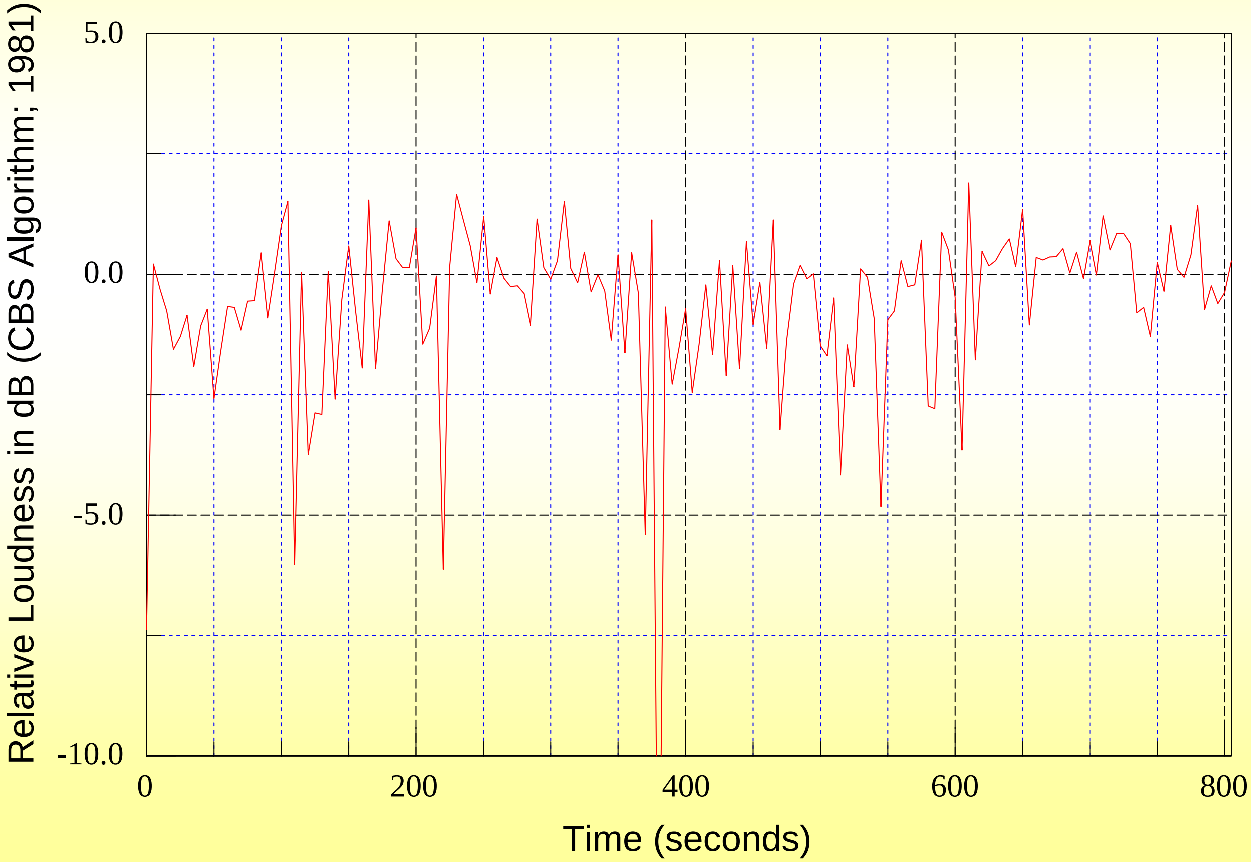


Audio Processing for Loudness Control

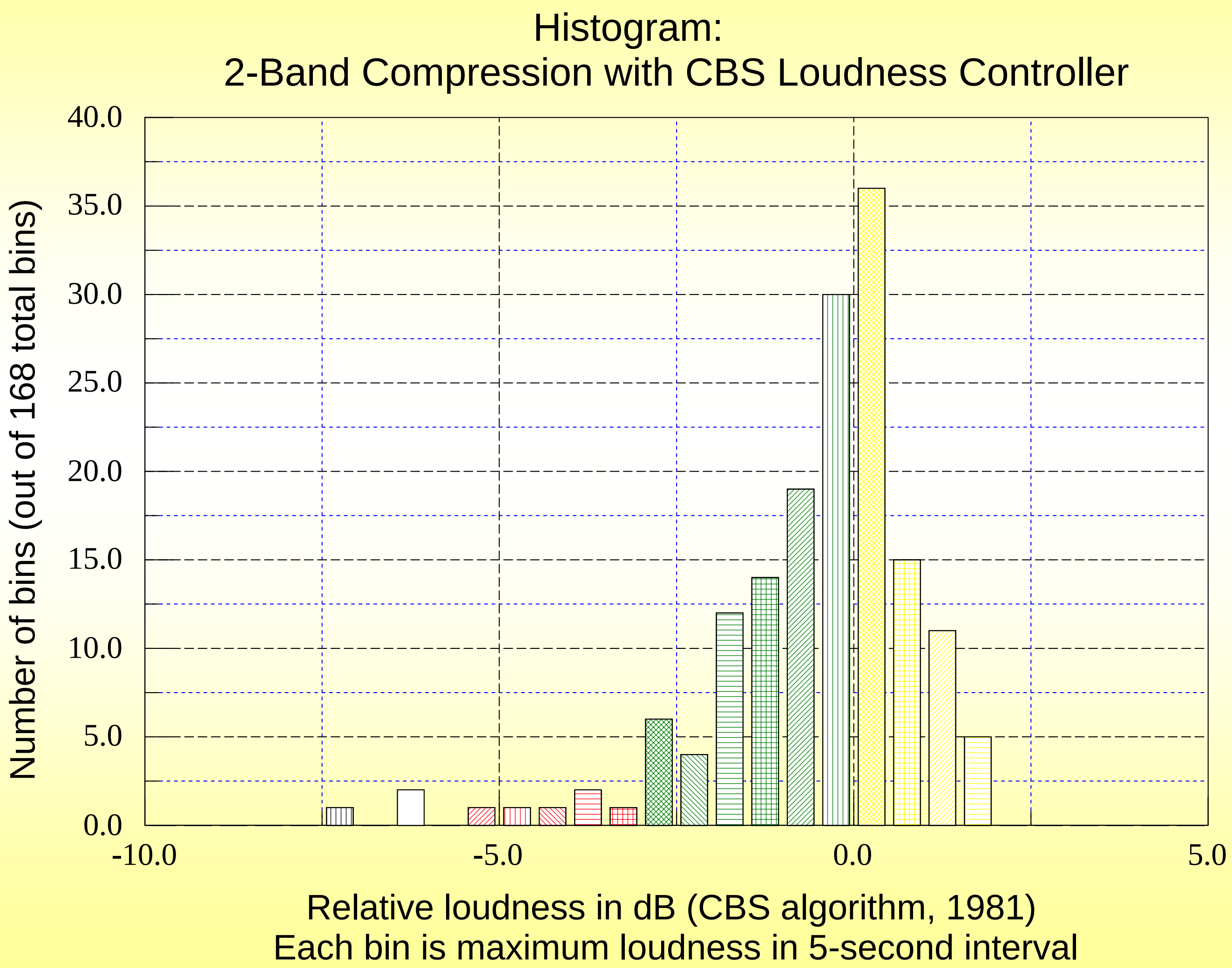
- The next measurements show the loudness consistency created by **2-band compression with automatic loudness control** (TV 2B+LC preset).
- Automatic loudness control significantly improves results, **preventing “esses” and commercials from sounding objectionably loud**.

2-Band Compression + LC

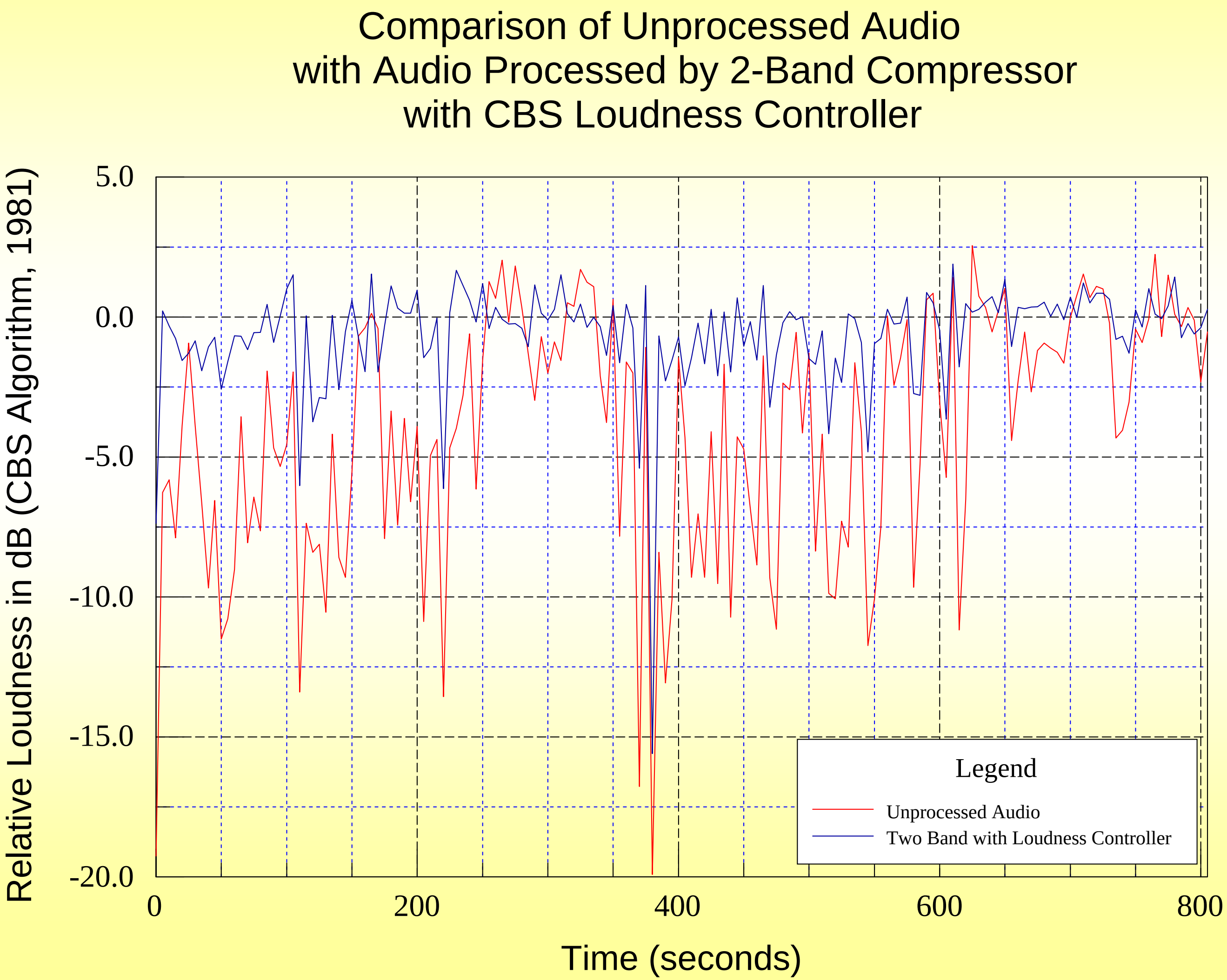
Loudness Control 2-Band with CBS Loudness Controller;
(each point is maximum loudness in 5-second bin)
Souce Audio is material is drama interspersed with commercials.



2-Band Compression + LC



2-Band Compression + LC



AGC + 5-Band Compression

- Good loudness control is also possible with **5-band compression preceded by a 2-band AGC**.
- Not just any multiband compressor will work. Every aspect of the compressor - thresholds, control loop dynamics, and crossover design – must be **carefully tuned** to achieve effective loudness control.
- The audio processor's *TV 5B General* preset was used for the measurements.

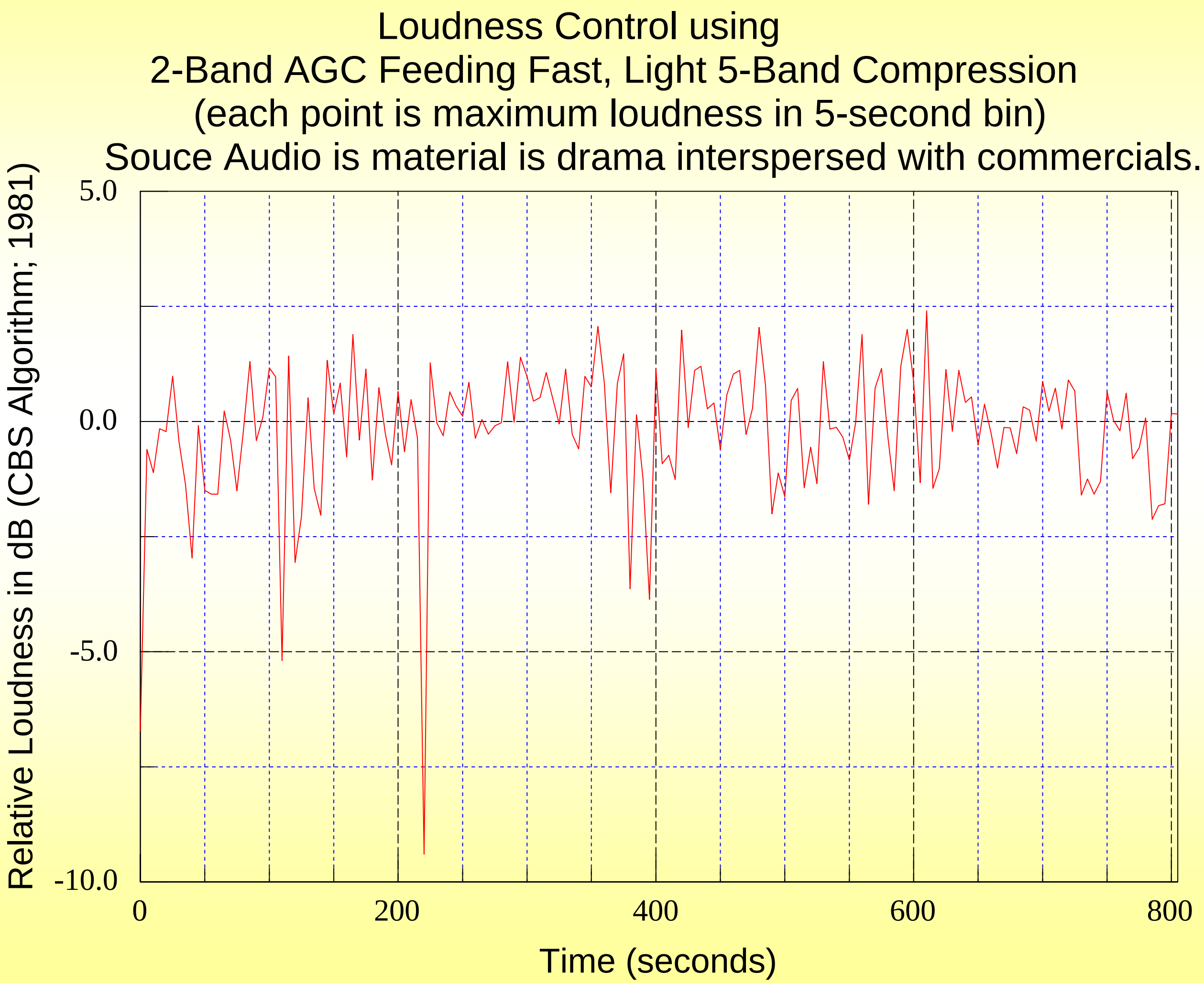
AGC+5-Band Compression

- Excessive loudness is often caused by **large amounts of midrange energy** that is added in production mixing to try to make the audio “pop.” **Commercials are notorious in this regard.**
- Program material that has not been **de-essed** can also cause objectionable loudness peaks.

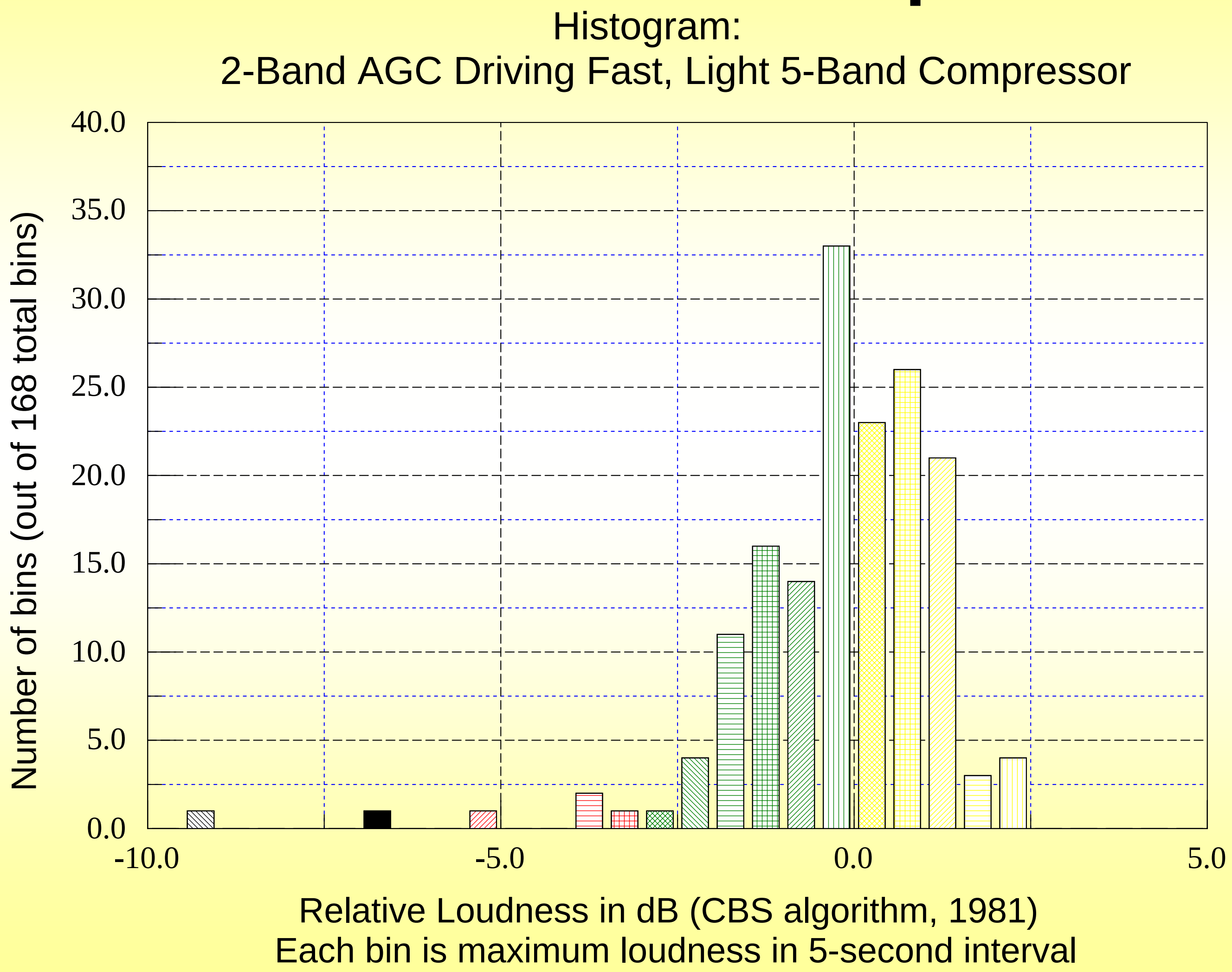
AGC+5-Band Compression

- 5-Band compression **automatically re-equalizes the spectral balance** to make the program more comfortable for the audience to hear – it tames harsh sibilance and dental-drill midrange.
- 5-Band compression is less likely than 2-Band compression to introduce **pumping caused by spectral gain intermodulation**.
- The slow AGC **controls average levels applied to the 5-band compressor**, preventing the compressor from **unnaturally increasing audio density**.

AGC + 5-Band Compression



AGC + 5-Band Compression



Comparing Processing

- **2-Band compression**: Does not control loudness well enough to avoid viewer annoyance in TV audio.
- **2-Band compression + CBS Loudness Control**: Effective loudness control that does not re-equalize midrange frequencies.
- **AGC+5-Band compression**: Effective loudness control that also prevents audible gain pumping caused by spectral gain intermodulation.
- **AGC+5-Band compression + CBS Loudness Control**: Most consistent loudness control; also prevents audible gain pumping caused by spectral gain intermodulation.

Processing Comparison

Loudness Control using Three Processing Styles:
2-Band, 2-Band with CBS Loudness Controller; 5-Band:
(each point is maximum loudness in 5-second bin)
Souce Audio is material is drama interspersed with commercials.

Conclusions 1:

- CBS/Orban automatic loudness control technology **effectively controls loudness but limits dynamic range as an inevitable side-effect**. Because of careful choices of compression ratios, time constants, and other subtle aspects of the processing algorithm, Orban processing limits dynamic range in a **graceful way that is not noticed by listeners**, who subliminally enjoy the resulting smooth, easy-to-listen-to texture.

Conclusions 2:

- In digital television, **some program material is well mixed and does not require automatic loudness control**. Automatic loudness control can be **bypassed** for such material.
- Other material, like **live news and sports, requires automatic loudness control to prevent viewer annoyance** – time pressures in live broadcasts prevent the audio from being carefully produced.
- Automatic loudness control is **unlikely to ever be as good as a human mixer** when the most esthetically pleasing results are desired. Only humans can understand the **subtleties of context**. But CBS/Orban automatic loudness control can please listeners and **prevent annoyance-driven tune-outs caused by inconsistent loudness**.