



Safely Driving Your Sound System



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1. Introduction

This application note offers knowledge and techniques that you can use to prevent loudspeaker failures caused by overdriving the sound system.

2. How Can Failures Occur?

In the old days, it was easy to tell when you were overdriving your sound system. There were a lot of clues. The loudspeakers were distorting, the limiters were pumping, the amplifier clip lights flashed like a metronome in sync with the music, and the gain reduction displays lit up like a Christmas tree. But these days, it seems like it's harder to tell when you are getting into trouble and easier to spin out of control and cause damage. Why is that?

One obvious reason is the amplifiers. Although amplifiers have physically gotten smaller over the years, their output capabilities have grown substantially. Amplifiers with continuous power ratings of 800 or 1000 watts into 8 ohms are now typical. What's more, amplifier designers have increased the instantaneous peak output capability to handle the dynamics of today's music. Instantaneous peak voltages of 140 volts are commonplace and the new state-of-the-art amplifiers like the Electro-Voice TG7 are capable of delivering 180-volt instantaneous peaks. That's a 4000-watt peak signal into an 8-ohm loudspeaker!

What is the advantage of that kind of peak power? You can reproduce a remarkable dynamic range from a large-scale sound reinforcement system – but only if the loudspeakers can handle those peaks.

The high power level presents two challenges to the loudspeakers. The first is to handle high peaks without sustaining mechanical damage. This damage could be instantaneous from a one time transient or could be long-term fatigue due to repeated high excursion. The second challenge is that the loudspeaker must sound good when reproducing those signal peaks.

Electro-Voice engineers are constantly working to improve the power-handling capacity of EV loudspeakers. They use state-of-the-art software and measurement systems to study the performance of the loudspeakers. As well, they spend a lot of time listening to them. They go to

great lengths to make sure the loudspeakers have the least amount of distortion possible at high peak levels.

The engineers also spend a lot of time driving loudspeakers to failure with proprietary test signals specifically developed to uncover their mechanical and thermal limitations – and then redesign the loudspeakers to withstand even more abuse.

However, no matter how robust a loudspeaker is, someone can always turn the level up even higher to cause failure. That's where the drive system's limiters come in. A limiter, if properly adjusted, can protect a loudspeaker from signal levels that could cause it to fail or degenerate.

Because no one knows the limitations of loudspeakers better than the engineers who designed them, Electro-Voice engineers developed peak limiter algorithms for each transducer model. When installed in a properly calibrated system drive chain, these algorithms will protect each loudspeaker in the system from explosive voltage peaks at damaging levels.

Digital limiters were chosen because they can do things that aren't possible with analog circuits. They can look ahead to know what's coming before the signal gets to the amplifier and can react to a signal peak within one sample period (20.8 microseconds at a 48 kHz sampling rate).

The result was EV's proprietary Peak Anticipation Limiter (PAL). These limiters limit peaks only when necessary, using the least amount of gain reduction required, then get out of the way. This minimizes the impact on the program material. Not only do the limiters protect the loudspeakers, they sound inaudible when protecting against "normal abuse". With most program material, gain reduction artifacts are not apparent until the gain reduction approaches 10 dB.

So where does the problem come in?

Over the years, sound engineers have become accustomed to listening and watching for certain cues which indicate when the system is being driven too hard. These include:

- Distortion from loudspeakers being overdriven.
- Pumping from limiters.
- Distortion from amplifier clipping.
- Amplifier clip light displays.
- Limiter gain reduction displays.

However, with the advancement of the Electro-Voice technology for improved loudspeakers and the new digital limiter protection algorithms, all of these audio and visual cues have been substantially reduced.

- Loudspeakers have been designed to be mated with today's large power amplifiers and have reduced distortion with the instantaneous peaks from those amplifiers.
- Digital peak limiters have been developed so that the gain reduction protection is inaudible with "normal abuse" and only begins to become noticeable when systems are severely overdriven.

- Digital peak limiters are so fast that they minimize amplifier clipping, which minimizes audible amplifier distortion.
- Digital peak limiters are so fast that the clip lights rarely light up on the amplifiers.
- Gain reduction is so fast with the peak limiters that the displays are only briefly activated, requiring the system operator to be attentive.

Although these changes represent technical advancements, they also serve to make it easier for you to overdrive your sound system without realizing it. The peak limiters will control potentially damaging instantaneous peaks and amplifier clipping without the usual audible and visual cues; however, the average power level of the signal will increase as the system is overdriven. If the system is severely overdriven for an extended period of time, the average power level may increase to the point of causing thermal damage to the transducers. That is the problem.

3. When to Turn the Level Down

The key to preventing overdrive failures is paying attention to the peak limiting indicators in your drive system. Attentive users will reduce the drive level when the peak limiters are repeatedly activated. This manual intervention will prevent the long-term average power from increasing to the point where thermal failures occur.

With most program material, the high-frequency and low-frequency limiters are the most likely to activate first. The midbass-frequency limiters are unlikely to activate unless the system drive level is substantially increased. The drive level should be reduced when any one of the three frequency band shows signs of recurrent peak limiting. (Note that, when subwoofers are used, there will be a fourth frequency band.)

In the case of the Electro-Voice rack-mount digital processors with full front-panel displays, the peak limiters can be monitored from the front-panel limiter LEDs. Each output band has an LED to indicate when the peak limiter is activated. When any one of the limit LEDs for any frequency band is activated for 20% of the time or more, the system drive level should be turned down.

In the case of the Electro-Voice software-controlled digital processors, the peak limiters can be monitored from the software limiter display. Each output band has a display to indicate when the peak limiter is activated. Although the actual limiter gain reduction in the software-controlled processors is just as fast as the rack-mount processors, the limiter displays in the software are not quite as fast as the rack-mount LEDs because the software display refresh rate can be slowed by network traffic. Thus, software limit lights tend to be less sensitive indicators of overdrive. Therefore, the level should be turned down when any one of the software limit indicators is occasionally activated.

4. What Else to Watch Out For

Besides managing drive levels, what else can you do to minimize the possibility of failures?

4.1. Update your firmware, software and presets.

As described above, the Electro-Voice engineers are continually improving the digital processing to provide the user the best performance with the best reliability. For example, the improved algorithms for the fast limiters for loudspeaker protection are only available if you have the latest firmware installed in your digital processor, along with the corresponding software for your computer and loudspeaker settings for your loudspeakers. Features like improved level displays and user interfaces are only available with the latest firmware and software releases. Loudspeaker settings updates may include revised protection thresholds, improved EQ voicing, improved gain structure and adjustments that are optimized for specific amplifiers.

For the best audio performance and the highest reliability, make sure you have the latest firmware, software and presets installed.

4.2. Use the correct limiter thresholds for the specific amplifiers being used.

Different amplifiers require different limiter thresholds. This is because not all amplifiers have the same gain and not all amplifiers clip with the same input voltage.

To protect the loudspeakers, the thresholds for the limiters in Electro-Voice presets are set to reduce the gain when the instantaneous voltage at the loudspeaker terminals is sufficiently high enough to cause damage to the loudspeaker. However, the voltage at the amplifier output will be dependent on the amplifier gain. This means that the limiter thresholds must be different for amplifiers having different gain. Consider an example where the limiter threshold is set to protect a loudspeaker when using an amplifier with a gain of 32 dB. If an amplifier with a gain of 38 dB is substituted without changing the limiter threshold, the second amplifier will deliver peak voltages 6 dB higher than the loudspeaker is capable of handling (four times the power – ouch!).

In addition, the peak limiter thresholds in Electro-Voice settings are set to prevent amplifier clipping. However, the level at which an amplifier clips is determined by its input sensitivity. Consider an example where the limiter threshold is set to prevent clipping for an amplifier having full output with a 0 dBu input level. If an amplifier having full output with a 6 dBu input level is substituted without changing the limiter threshold, the second amplifier will be limited to 1/4 of its output power capability.

Using the wrong limiter thresholds for an amplifier can result in destroyed loudspeakers, amplifier clipping or reduced acoustic output capability. Contact Electro-Voice Technical Support to make sure you are using the right limiter thresholds in the digital processors to match the amplifiers you are using.

4.3. Don't turn down the processor analog output knobs or the amplifier input knobs.

Turning down the analog output knobs on the processor or the input knobs on an amplifier effectively reduces the gain of the amplifier. This means that the recommended limiter thresholds are no longer matched to the amplifier, causing problems as described in the previous section.

It should be noted that, in some specific circumstances, it may be acceptable to turn down processor output knobs or amplifier input knobs. For example, it may be necessary to turn down the amplifiers powering the loudspeaker boxes that cover the front rows of an audience to get even sound pressure level in the seating area. This is acceptable, even though the limiters are mismatched to those amplifiers, because those amplifiers are intended to have reduced output. One should never, however, turn down the amplifiers for an entire array.

4.4. Don't clip the input of the digital processor.

As mentioned above, if the output limiters in the processor have significant activity, the drive level should be reduced. However, if the console level continues to be increased, the input of the digital processor may be overdriven as well as the loudspeakers.

Besides introducing full-range distortion, this can create dangerous high-voltage square waves which the amplifiers will reproduce and deliver to the loudspeakers. Because the signal peaks are clipped, the SPL peaks are also limited. If the operator continues to turn up the system to get more acoustic level, the continuous level to the loudspeakers could be increased to a high enough level to cause thermal failures.

Note that turning down the input digital gain will not reduce input clipping. The clipping occurs at the beginning of the signal chain in the processor where the analog signal is converted to a digital signal. Thus, the signal is already clipped before it gets to the input digital gain (or any subsequent EQ or level adjustments).

Input clipping is most accurately monitored from the front-panel input clip LEDs on the digital controllers. With computer controlled software, the clip displays in software may not be as fast as the front-panel LEDs (because of network traffic as described above for limiter displays).

Whenever input clipping is observed, the drive level should be turned down.

4.5. Don't use the output compressors in the system processor.

Compressors are often used to reduce the dynamics of the of the program signal for artistic reasons. This is best implemented on individual input channels and not on the entire sound system.

Compressing the outputs of the signal processor reduces the sound pressure level capability of the sound reinforcement system. This encourages the sound system operator to turn the drive level up to get the desired SPL. Because the dynamic range is compressed, its average power is increased. Continuous excessive average power to the loudspeakers will cause thermal damage.

4.6. Use the Electro-Voice LAPS software and aim the loudspeakers correctly.

One of the advantages of a line array system is that you can tailor the vertical output of the array to match the seating area of the venue to get even sound pressure levels from front to back. The tall vertical height of a line array allows the user to achieve a very narrow vertical coverage angle

that, indoors can be used to minimize the sound energy that bounces off the roof and, outdoors can be used to achieve high sound pressure level at long distances away from the array. These benefits can only be obtained if the boxes are correctly aimed. If aimed incorrectly, the results can be disastrous.

For example, if aimed correctly, a line array is an excellent sound reinforcement tool to use at an outdoor festival where the listening area is a long flat plane. However, one mistake that we see users make in a situation like this is to incorrectly aim the boxes. The result can be a very narrow vertical coverage pattern that is directed just above the heads of the audience (as shown in Figure 1).

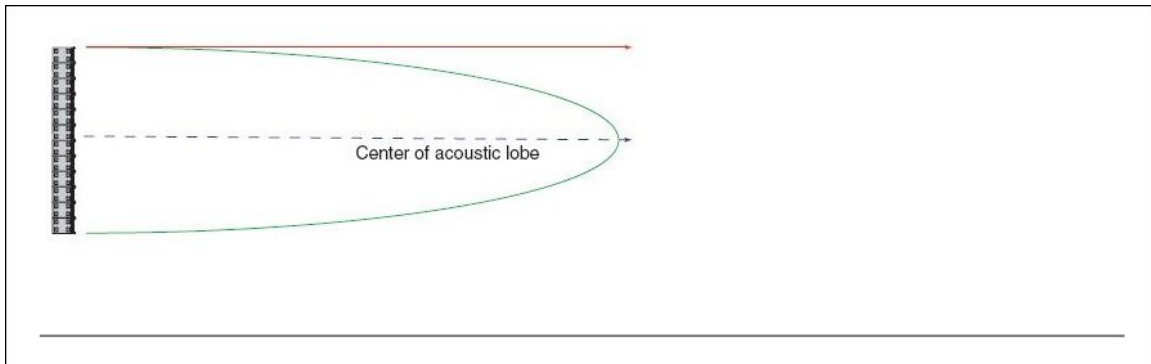


Figure 1 – Array Aimed Too High

Not realizing that most of the sound is aimed above the audience, the user may turn up the drive level until the system is in severe overdrive in a futile attempt to get enough SPL in the listening area (causing loudspeaker failures in the process). If only they had realized that, 20 feet up in the air, the SPL was 20 dB louder!

On the other hand, if the array is aimed too low, the SPL can be insufficient at the back of the listening area, but become too high as one moves towards the array (as shown in Figure 2).

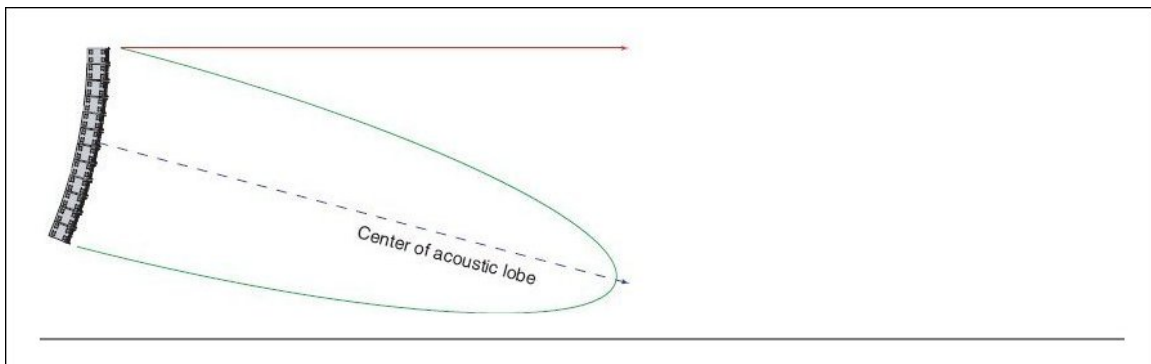


Figure 2 – Array Aimed Too Low

Electro-Voice created the Line Array Prediction Software (LAPS) for two reasons. The first is to enable users to get the most even sound pressure level and the most consistent frequency response throughout a venue with the loudspeaker system. The second reason is to avoid potential problems like the ones described above. Taking the time to use the software to design

the array for the specific venue and to aim the loudspeakers correctly is a worthwhile investment of time to maximize audio performance and minimize loudspeaker failures.

4.7. Don't boost the high-frequency EQ to overcome air losses when outdoors.

One of the properties of air is that it absorbs high frequency energy – the higher the frequency, the more the absorption. The high-frequency attenuation is accumulative, so the further away from the sound source, the more the attenuation. Furthermore, the absorption is greater when the air temperature is higher and the relative humidity is lower.

This phenomenon is not readily apparent indoors because the distances are not as great. Outdoors, however, the attenuation can be quite substantial. For example, the level at 10 kHz will be attenuated approximately 14 dB at a distance of 300 feet(91.4 m)! (See Figure 3.)

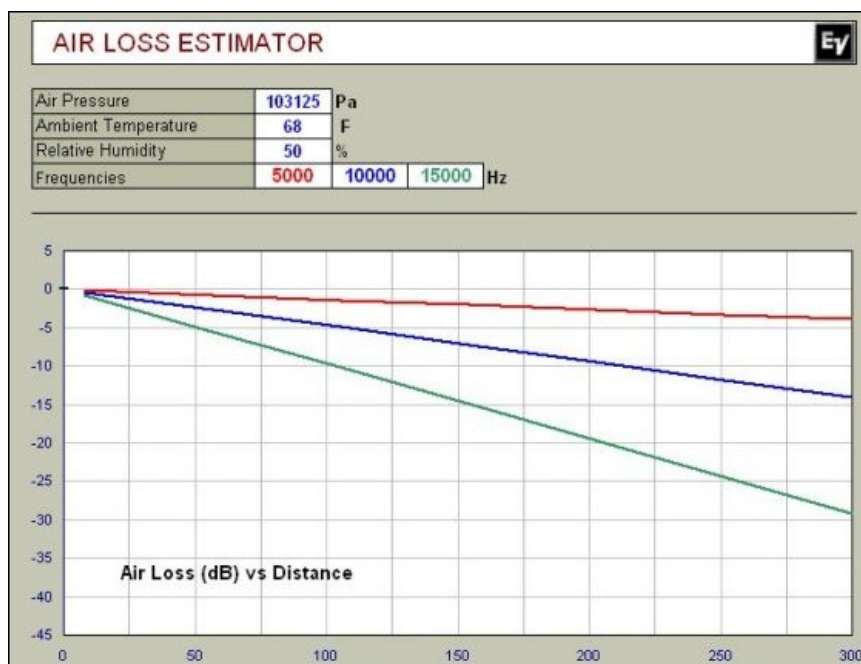


Figure 3 – Air Attenuation at 300 Feet (91.4 m)

One should not attempt boost the high-frequency EQ to overcome large air absorption losses, because such a substantial boost would result in system overdrive at high frequencies. Instead, consider using supplementary delay clusters located in the audience area (usually behind the mix site).

4.8. Check your SPL meter – It may be louder than you think.

We started out by talking about how the advancement in technology has reduced many of the audible distortion cues that we have been accustomed to hearing when a sound system is being overdriven. The same sonic improvements that challenge our perception of how hard we are driving a system also challenge our perception of how high the sound pressure level is.

Our ears perceive distorted signals to be louder than undistorted signals at the same level. Since new-technology sound systems are less distorted than older ones, they will often not seem to be as loud as they actually are.

You should always monitor the SPL to know what levels you are producing – not only for the protection of the ears of the audience, but also for the protection of the sound system. Any SPL meter will do (including the ubiquitous RS model). Set the weighting for “Flat” or “C-Weighted” and the response time for “Fast”.

We are aware of a concert tour that briefly considered miking the pyrotechnic explosions because they weren’t loud enough compared to the music. Fortunately, the front-of-house engineer pulled out an SPL meter for a reality check and, upon realizing that the sound system was louder than they had expected, turned the music down instead of trying to amplify the explosions. (Talk about blowing up your sound system!)

4.9. Take enough loudspeakers and amplifiers to the gig!

While this seems like an obvious statement, there sometimes are practical considerations that limit the size of the sound reinforcement system for a venue or an event (budget limitations, weight restrictions, space restrictions, truck limitations, etc.). When an undersized sound reinforcement system is used, the opportunities for overdriving the system are significantly increased. Be extra careful in these situations.

4.10. FIR filters compared to IIR

In the past, the predominant filters in digital processors have been IIR. However, as the cost of digital signal processing has come down, FIR filters are becoming more predominant. FIR filters offer a performance advantage over IIR filters for two reasons. The first is that equalization magnitude and phase can be controlled more precisely with FIR filters. The second is that steeper crossover slopes are possible with FIR filters.

Not all FIR filters are created equally. Electro-Voice engineers have developed a proprietary means of creating FIR filters that offer greater accuracy and extend their accuracy to lower frequencies. This we believe offers a performance advantage. This means that FIR filters for Electro-Voice loudspeakers are only available in Electro-Voice digital processors.

Is there a difference between IIR filters and FIR filters with regards to overdriving a sound system? Technically there is no difference. Because the phase is typically more precisely controlled with FIR filters, there may be a difference in instantaneous peaks, but the long-term continuous power delivered to the loudspeakers will be the same.

However, because there are sonic improvements with FIR filters, some of the audible cues that the sound system operator is accustomed to hearing will be further reduced with FIR filters compared to IIR filters. As described in previous sections, this means that the operator may not perceive the system as being driven as hard as it is, increasing the opportunity for overdriving a system. All of the advice from the previous sections for minimizing the possibility of loudspeaker failures are equally applicable to FIR filters as to IIR filters.

5. Let Us help Fine Tune Your System

Let us help you get the most out of your sound reinforcement system with the highest reliability. We can make sure that you have the best loudspeaker settings, firmware and software for the loudspeaker, processor and amplifier combination that you are using, and the most up-to-date support literature and software.

Contact one of the Electro-Voice Technical Support Team at one of the locations listed below.

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