Digital loudspeaker management

OMNITRONIC DXO-26E
Digitaler Controller

Digital loudspeaker controllers are the heart of every modern PA-system. Controllers assign the matching signal to every speaker, balance inconsistencies in the frequency range and protect the system from overload.

Loudspeaker controllers normally consist of these three important components:
- the hardware including the connectors and interfaces, the transducers, the operating elements and the housing.
- the firmware includes algorythms for signal processing, i.e. equalizers, crossovers, limiters and delays.
- the software providing a graphical surface on the user's computer for adjusting all controller functions and settings and manage complete setups.

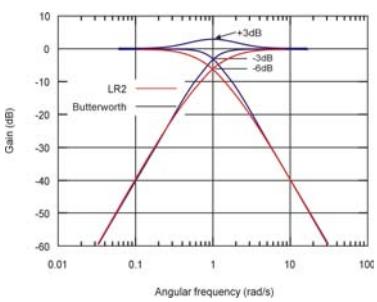
Before the digital era, most audio controllers were not much more than active crossovers, they did not have several features like preset memories and password protection. Some of these controllers did not even have variable crossover frequencies, the only possibility was to exchange one crossover by another. These controllers were mainly designed for one special speaker-system and could not be used very flexibly.

In the meantime, powerful digital management systems are also affordable for amateurs and semi-professional users. Subwoofers are only seldomly operated via passive crossovers, but rather separated from the hi/mid speakers via controllers. The "bad thing" about the digital revolution is that many users are overwhelmed by the quantity of functions.

Due to the limited space of this article, we cannot discuss every part of a modern audio controller but hope to supply the reader with some important basic facts in order to handle his digital controller.

Controllers are installed after the mixer, or if available after the graphic equalizer in the signal chain. In this case, the equalizer is not for correcting the frequencies in the speakers, but adjusting the PA-system to the acoustic characteristics of the venue.

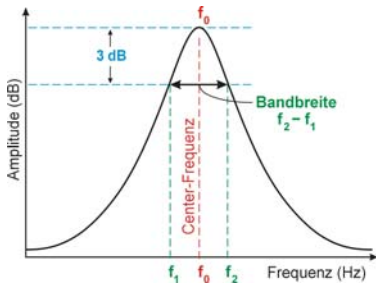
The first important task of a controller is adjusting the signal levels. It is common practice to have the power amplifiers at full gain controls in order to prevent them from manipulation because amptown is mostly far away from the sound engineer. Furthermore, the levels of different speaker ways of an actively separated system must be balanced to a matching ratio.



Before that, the incoming sum signal has to be separated to the different speaker sizes. For doing so, most controllers offer different filter types and slopes. The filter characteristics mostly differ in their way of behaving at their specified working field. While butterworth filters lower the level at the crossover frequency by 3 dB, Linkwitz-Riley filters, which are based on a number of butterworth filters, lower the level by 6 dB. The advantage of this characteristics is the constant level in the crossover area from one frequency band to another. In order to realize such constant level with butterworth filters, the working area of the first frequency band's lowpass filter and the second band's highpass filter have to be exactly calculated and then separated.

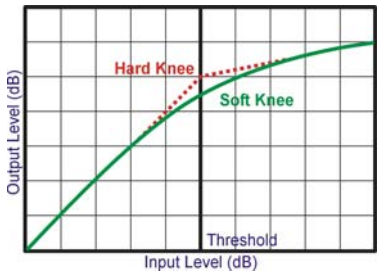
When using Linkwitz-Riley filters, the upper and lower crossover frequency of consecutive frequency bands can have the same frequency. The mostly available Bessel filters have a less strong bended amplitude compared with Butterworth filters, but a better frequency response and constant group delays. Common abbreviations for Butterworth is BW, for Linkwith-Riley L-R (not to be mixed up with left/right).

The Butterworth and Bessel filters are mostly available with 6, 12, 18 and 24 slopes, sometimes also 36 and/or 48 dB per octave. Linkwitz-Riley filters are only available in 12 dB per octave, while 24 dB is one of the mostly used slopes for crossover frequencies. Slope means how fast the amplitude is lowered after reaching the crossover frequency. For a lowpass filter with a 12 dB per octave slope and a crossover frequency of 1 KHz, the amplitudee at 2 kHz is 12 dB lower as at the crossover frequency (frequency doubling equals one octave). For a Butterworth filter, this is –15 dB, for a Linkwitz-Riley filter this is –18 dB. In theory, filters with quasi infinite slope were also possible, but this would hamper the phase of the signal and thus the sound very much.

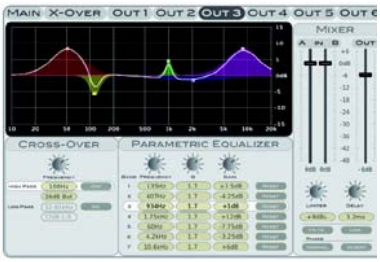


Another very important tool of loudspeaker controllers are the equalizers. The frequency range of a PA-system can easily be corrected with fully parametric equalizers. While mixer equalizers are mostly semi-parametric, i. e. only amplitude and frequency can be changed, a fully parametric equalizer can also change the filter bandwidth or shape of the bell. Consider that a high filter bandwidth (Q-factor) equals a small bandwidth and vice versa. As already mentioned, too harsh adjustements of the frequency response have to be avoided because the phase problems make the positive effects of the correction void. Here, less is often more!

Almost every controller also features a delay function for delaying the signal, although there are major differences. The sense of a delay is a time shift of the signal for a second loudspeaker line far away from the main PA. These delay lines in a distance of 30 or 50 meters from the stage in the middle of the audience must be delayed in respect to the speed of sound so that the sound from the main PA and the delay lines is not different. The second use of delays is the time shift correction within the main PA. If the subwoofers position is in front or behind the high/mid speakers, this can also be corrected with a little delay. Also coaxially installed speakers, e. g. a horn in front of a mid woofer, must be corrected in their time shift as phase deletion may occur in the centre of both signal sources. The phase of some speakers must be turned by 180° which can also be realized with a controller.



One of the most important protection circuits of larger PA-systems is the limiter which can also be found in most audio controllers. There are peak limiters absorbing short impulses and thus protecting the speakers from mechanical damage and RMS limiters controlling the average audio level and thus the thermal strains of the speakers. Last but not least, limiters can help to fulfill noise protection regulation. Important parameters are the attack time (how fast the limiter should react) and the release time (how long the level should be lowered). The threshold is the value at which the limiter starts reducing the level. Ratio describes the strength or ratio of the compression (1:1 means no compression, 10:1 and more is called limiter). Limiters represent an extreme form of a compressor and mostly have a fixed ratio. They also differ in their response behaviour: hard knee means that the amplitude is immediately bent when reaching the threshold while soft knee means a softer transition already starting before the threshold.



System controllers are mostly designed in 1 unit rack format and thus quite uncomfortable when using the operational elements. Most controllers can be controlled via USB, RS232 or ethernet from a pc or MAC. Via a graphical surface, all functions are available and in many cases, the present levels are also monitored. Several presets for different settings can be filed on a computer and be transmitted to the controller when needed. For special applications like permanent installations, controllers are also built without operational elements and can thus only be controlled via computer. This also provides higher protection against misuse.

Signal input is either analog or digital (e. g. AES/EBU or network protocols like CobraNet), the output signals for the amplifiers are normally analog.

Certain controller areas can be blocked via passwort hierarchies which is a decicive advantage for permanent installations or dry hire.

Practical tipps:
If a preset is not provided by the manufacturer, presets have to be created with one's own ears. As a starting point the following frequency ranges of loudspeakers may be used:
18“ subwoofers: from 35 Hz to 90/100 Hz
15“ subwoofers: from 45 Hz to 120 Hz
Mid woofer: from 100/120 Hz to 1.5/2.5 kHz
Highs: from 1.5/2.5 kHz

These values are only a rough orientation. Other factors like high speaker size and mid woofer size along with the kind of material (CD or live) also have to be considered.

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