TI 330
Cardioid Subwoofer Array – CSA 1.4 en
(CSA function within the d&b amplifiers)

d&b audiotechnik

1. Introduction

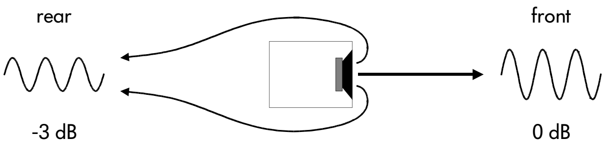
CSA enables the combination of three or a multiple of three subwoofer cabinets in an array to provide exceptional directivity at low frequencies. It can be applied to either d&b Q-SUB, B6-SUB, B2-SUB or B22-SUB cabinets, when driven by applicable d&b amplifiers. The d&b amplifiers provide a selectable CSA function for these applications.

High directivity at low frequencies has two main effects on the sound reproduction.

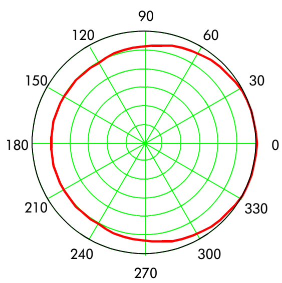
- In closed venues the diffuse sound field at low frequencies is reduced and acoustic room modes are excited to a much lower degree. The improved ratio of direct to diffuse sound in the systems' coverage area provides a much more precise low frequency reproduction.
- The low frequency level behind the subwoofer cabinets and as a result its influence on stage sound is greatly reduced. The maximum gain before feedback is increased.

2. Directivity of subwoofer cabinets

To achieve a useful directivity, a sound source has to have at least the dimensions of the wavelength it radiates. Audio frequencies cover a 20 Hz to 20 kHz band which results in wave lengths from 17 m (56 ft) to 1.7 cm (0.7"). The typical operating range of subwoofer cabinets is 35 Hz to 120 Hz, the corresponding wavelength is 10 m (33 ft) to 3 m (10 ft). Therefore the directivity of a subwoofer or subwoofer array of a given size depends on the frequency. The rejection to the rear for a single cabinet is very small. For a typical 18" subwoofer it is usually about 3 dB at 70 Hz.



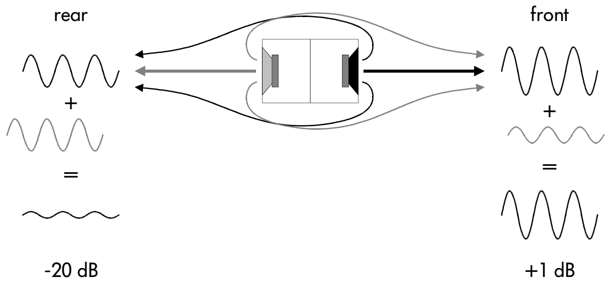
Larger arrays increase the directivity. A stack of three subwoofers provides about 5 dB rejection, displayed in the polar diagram below.



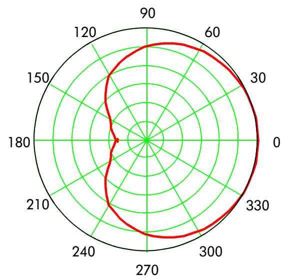
To achieve a useful directivity in both the horizontal and the vertical planes (e.g. to avoid interference by low frequencies behind the system), a very large (wide and high) subwoofer array is required.

3. Cardioid subwoofers

A cardioid subwoofer cabinet is a method of increasing directivity at low frequencies without the need for very large arrays. The principle is the introduction of a second sound source at a defined distance behind the main source which cancels the sound energy radiated by the main array to the rear. To work effectively, i.e. to cancel the energy at the rear and not at the front, the length of the sound path from the rear source to the front has to be in the magnitude of a quarter of the wavelength to be controlled by the system. To achieve the desired cancellation of the sound, phase and level of the rear source have to be aligned by separate signal processing and amplification.



The resulting polar diagram shows a cardioid pattern.

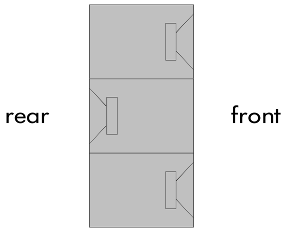


As the wavelength varies with frequency and the distance of the sources remains constant, this principle only works for a fraction more than an octave, just enough for the typical bandwidth of a subwoofer. Within this bandwidth there are frequency ranges where a tuning for best cancellation to the rear does not give the maximum possible output to the front. So the overall sensitivity to the front of a cardioid arrangement is naturally lower than that of a conventional setup consisting of the same components.

4. Cardioid Subwoofer Array - CSA

Common cardioid subwoofer designs employ relatively large cabinets fitted with low drivers and/or ports at the front and rear. d&b has devised a method that uses omnidirectional subwoofers in a so-called **CSA** (**C**ardioid **S**ubwoofer **A**rray) setup. The CSA generates an uncompromised cardioid behavior, which means that there is no need for special cabinets, enabling the use of the system's full efficiency when there are no particular requirements for low frequency directivity.

In its minimum configuration a CSA setup consists of a stack of three subwoofer cabinets. Due to the directivity of the cabinet arrangement only one subwoofer is needed to compensate for the energy of the other two radiating to the front. For reasons of symmetry the cabinet facing to the back should be located in the center of the column.



The front facing subwoofers are driven by amplifier channels without any additional filtering. Two front facing subwoofers may be driven in parallel by one channel. The rear facing cabinet is driven by a separate channel with additional filtering (CSA function selected).

The diagrams below show the vertical and horizontal isobar plots of the CSA. It produces a constant directivity with 180° dispersion and a minimum rejection of 15 to 20 dB to the rear.

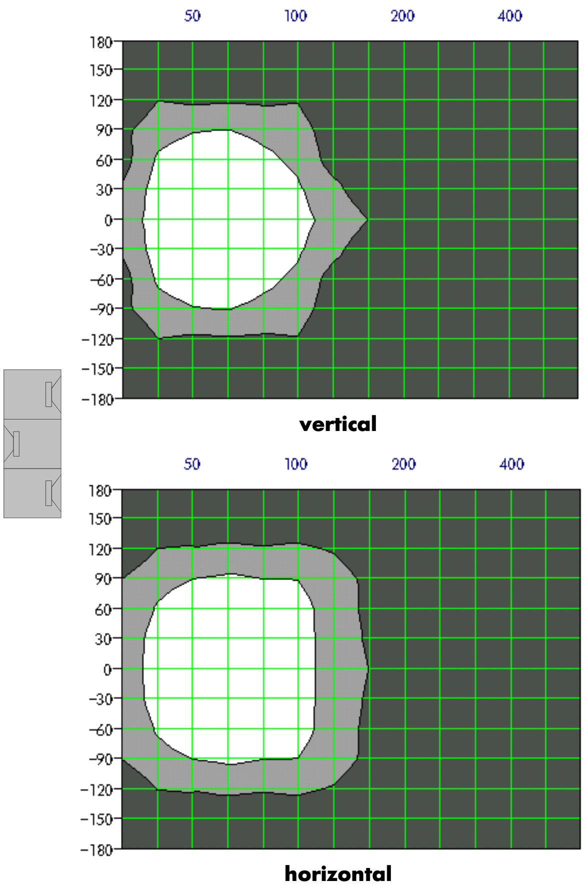
The phase response to the front of a CSA is almost identical to a standard setup so the crossover settings relating to the top cabinets still work in the same way.

The contribution of the reversed subwoofer cabinet to the sound radiated to the front is only significant at very low frequencies (approx. +2 dB). So compared to a conventional setup the tonal balance of the CSA is slightly shifted towards lower frequencies. Depending on the application this may be compensated for by selecting the higher crossover frequency on the subwoofer controllers.

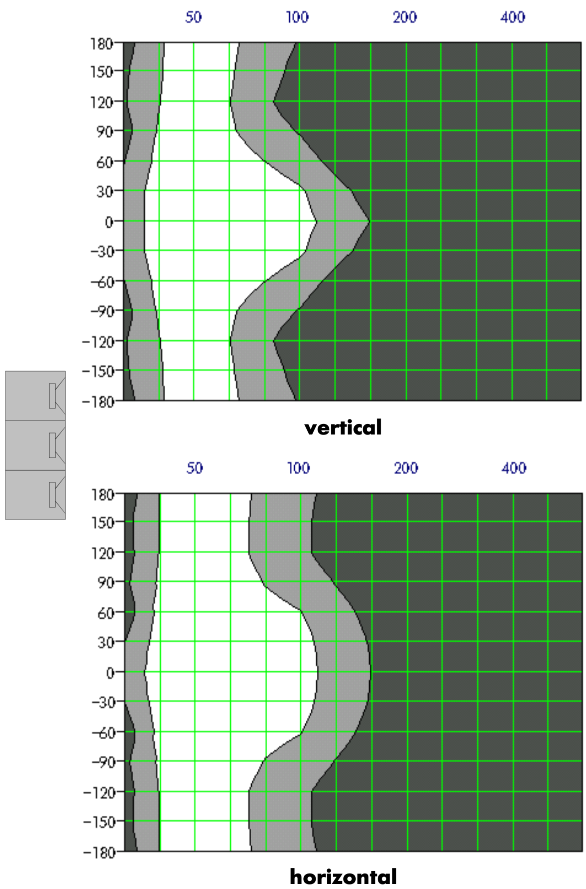
Q-SUB: standard = 130 Hz instead of 100 Hz
B6-SUB: standard = 140 Hz instead of 110 Hz or INFRA
B2-SUB/B22-SUB: standard = 100 Hz instead of INFRA (70 Hz)

When placing the CSA stack, keep a distance to walls or other obstacles of at least 60 cm (2 ft) in order not to affect the radiation of the reversed cabinet.

Please note that placing a CSA stack directly at the rear wall of a room is not useful. Use a conventional stack for this application.



Dispersion characteristics of a CSA of Q-SUBs. Isobars for -6 dB and -12 dB versus frequency (x) and angle (y).

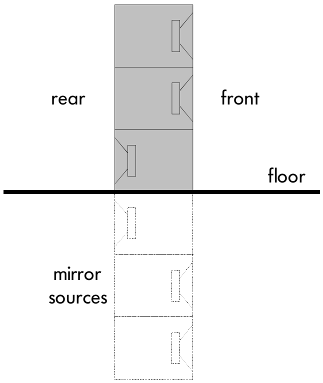


Isobar plots of a conventional array, 3-high

5. System configuration

To achieve the best rejection to the rear, the mechanical setup of the system has to be very accurate. With Q-SUB, B6-SUB and B22-SUB systems, use the runners and recesses in the cabinet top and bottom panels to align the cabinets. All amplifiers driving the subwoofers have to be set to the same input gain and fed with the same input signal. Only the amplifier channel driving the rear subwoofer has to be set to CSA. All other parameters of the amplifier channels have to be configured identically, including delay and equalization, if used.

If the array is stacked directly on the ground, which reflects low frequencies, symmetry is also achieved by rotating the lowest cabinet in the column as shown below.

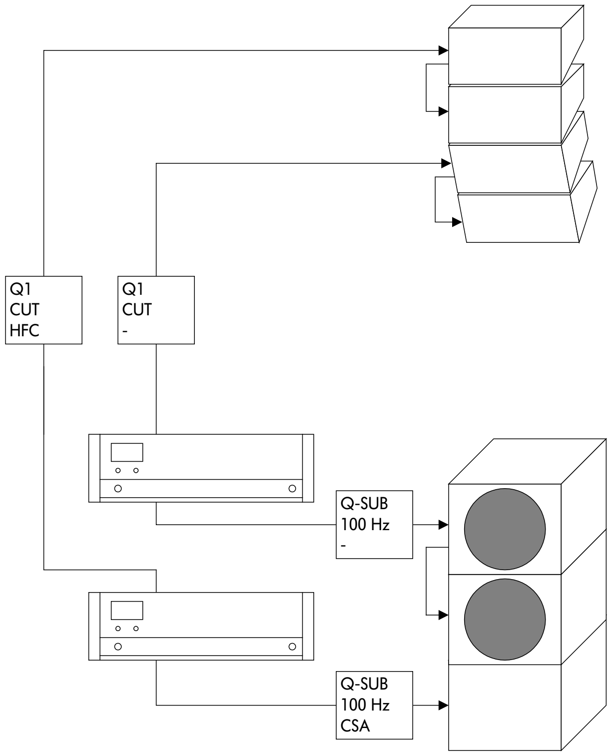


The CSA also works in other mechanical configurations provided the effective path length from rear to front drivers is identical. For example, when the subwoofer cabinets are arrayed horizontally on the floor, vertical and horizontal directivity is provided without the need for high SUB columns.

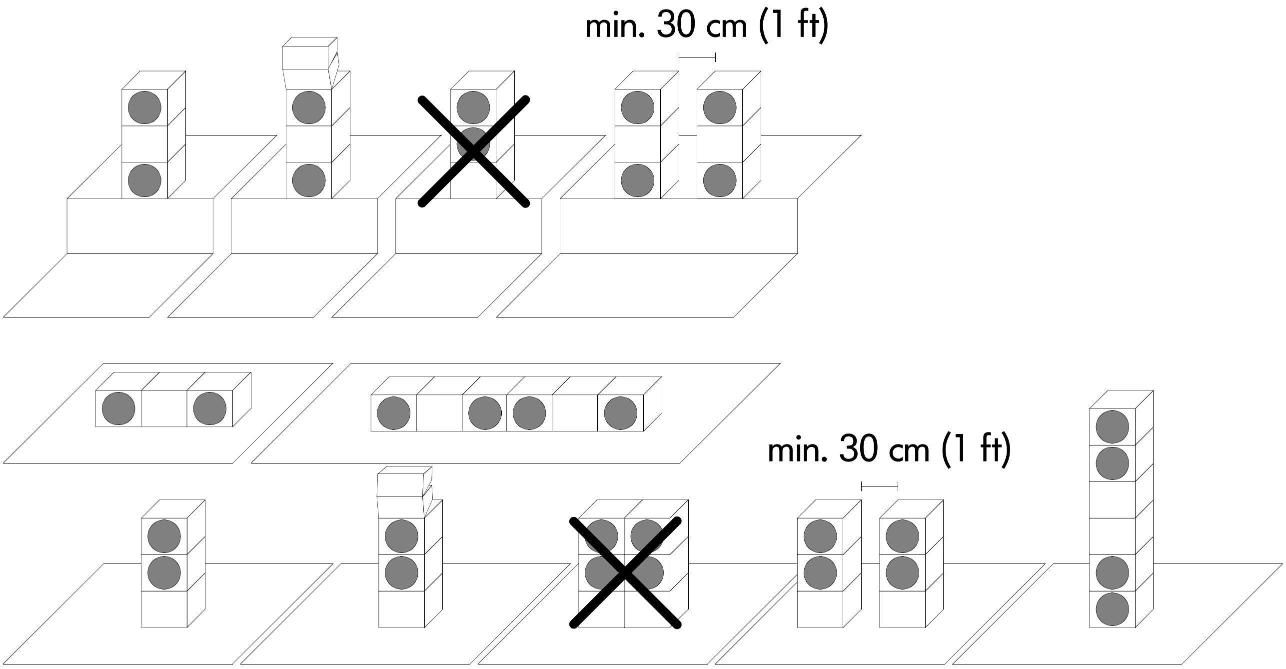
Q-SUB/B6-SUB configurations

Possible setups using the CSA function are shown below (front of house view).

When wiring the system, please note that front radiating subwoofers may not be daisy chained with reversed subwoofers. All reversed cabinets have to be driven by amplifier channels set to the corresponding setup and CSA mode, all others should be driven by channels without CSA selected. The gain and crossover settings (standard / 100 Hz) have to be identical.



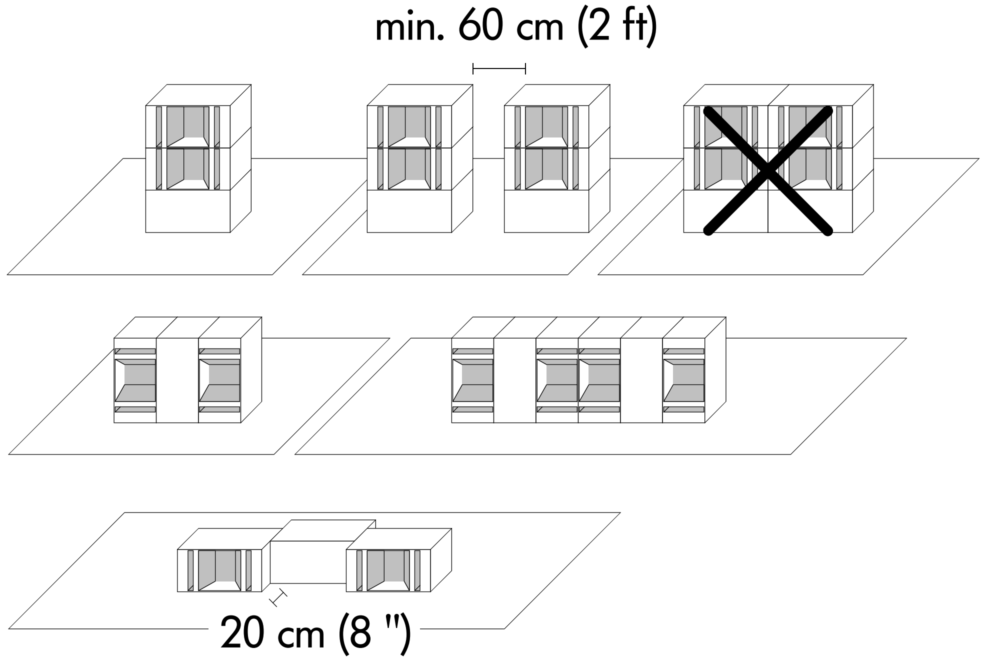
Q1/Q-SUB CSA wiring example



B2-SUB/B22-SUB configurations

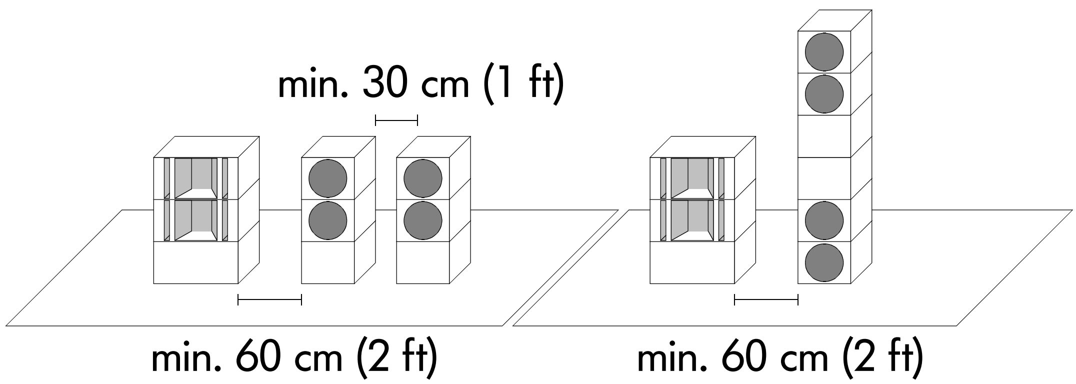
All reversed cabinets have to be driven by amplifier channels set to B2-SUB/B22-SUB/INFRA and CSA mode, all others should be driven by channels set to B2-SUB/B22-SUB/INFRA configuration without CSA selected.

Please note that when extended bandwidth of a CSA using B2-SUB/B22-SUBs is necessary, the standard configuration may also be used (i.e. INFRA not selected, e.g. to support a Q1 system without Q-SUBs/B6-SUBs), raising the crossover frequency from 70 Hz to 100 Hz. The dispersion control above 70 Hz, however, will be less accurate than below.



Mixed configurations

CSA stacks of B2-SUB/B22-SUBs and Q-SUBs/B6-SUBs can be combined. The recommended distance is 60 cm (2 ft).



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