

FUNKTION-ONE[®]

Resolution 4T, 4E, 4S & 4D User Guide



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1 Thank you

Thank you for purchasing a Funktion One Resolution 4 system. All Funktion One loudspeaker systems are designed and built in England. Our design philosophy is to achieve outstanding sonic accuracy and efficiency through innovative acoustical design rather than relying on headroom-robbing equalisation. This approach provides an audible sense of immediacy and involvement reminiscent of the finest musical instruments.

2 Receiving, unpacking & handling

Check your shipment against your order to make sure it's complete and in good condition before signing for the delivery.

2.1 System contents

There are several types of Resolution 4, depending on the application.

Resolution 4T touring system

Each Resolution 4T comprises:

- 1 x Resolution 4T complete with:
 - Integral flying system
 - Captive inter-cabinet/input cable
 - Wheelboard

Options and accessories available

- SC5G (grey) or SC5B (black) scrim
- GSS-ResT ground stack tilt strap
- Multi-column FG series flying grids
- BR5 series chain bridle and bow shackles for flying grid
- H505 chain hoist for grid levelling
- CH5 column hangers
- TS5 flying system tilt strap
- Resolution 4D downfill system
(When used with Res 18 on FG53 or FG55)

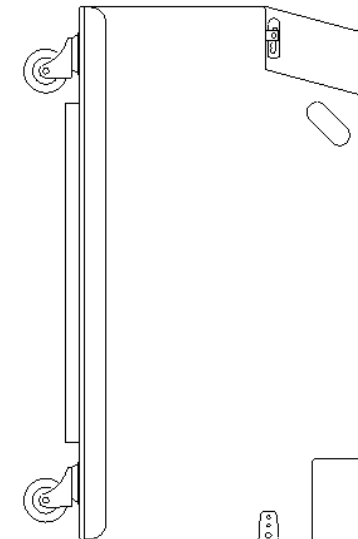
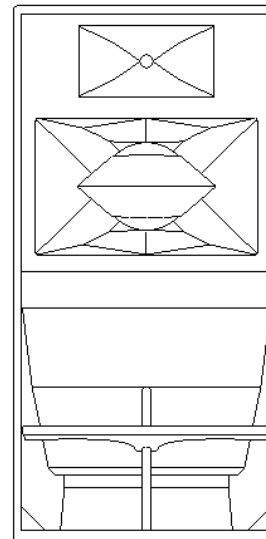


Fig 2.1-1 Resolution 4T

Resolution 4E - basic version for installations and medium scale events

Each Resolution 4E system comprises:

- 1 x Resolution 4E complete with:
 - Integral M10 fixing points
 - EP6 in & link

Options and accessories

- Choice of ceramic or neodymium drivers
- WB5 wheelboard
- SC5G (grey) or SC5B (black) scrim
- GSS-ResE ground stack tilt strap
- Dedicated installation flying hardware
- Optional flying system for occasional rigging/de-rigging operations

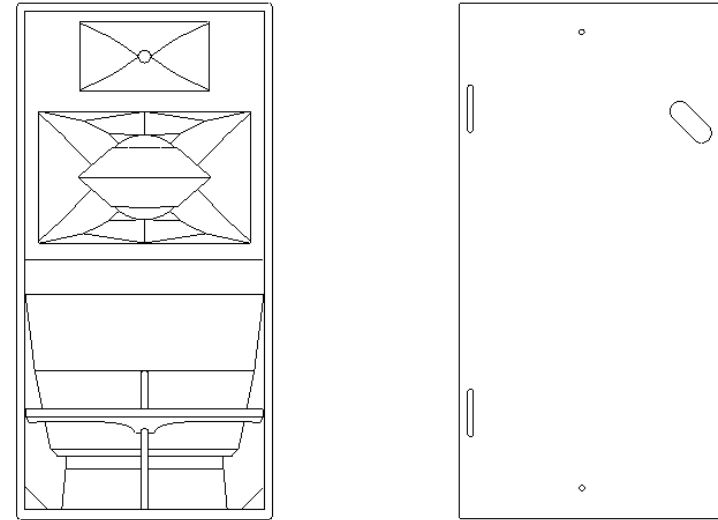


Fig 2.1-2 Resolution 4T

Resolution 4S skeletal system

Each Resolution 4S system comprises:

- 1 x Resolution 4S complete with:
 - Integral lifting points (May be attached vertically or horizontally depending on the required enclosure orientation)
 - Sprung terminal connectors

Driver options

- Choice of ceramic or neodymium drivers

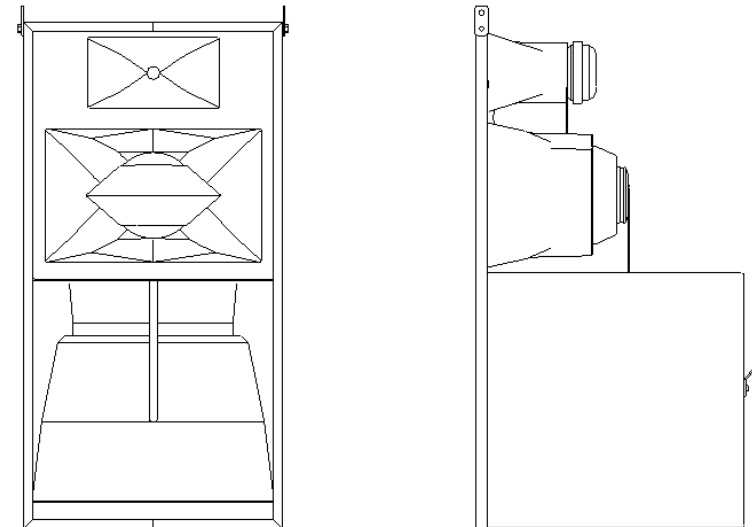


Fig 2.1-3 Resolution 4S

Resolution 4D downfill system

Each Resolution 4D comprises:

- 1 x Resolution 4D complete with:
 - Integral flying system
 - Captive inter-cabinet/input cable

Options and accessories available

- Optional scrim
- Multi-column FG series flying grids
- BR5 series chain bridle and bow shackles for flying grid
- H505 chain hoist for grid levelling
- CH5 column hangers
- TS5 flying system tilt strap

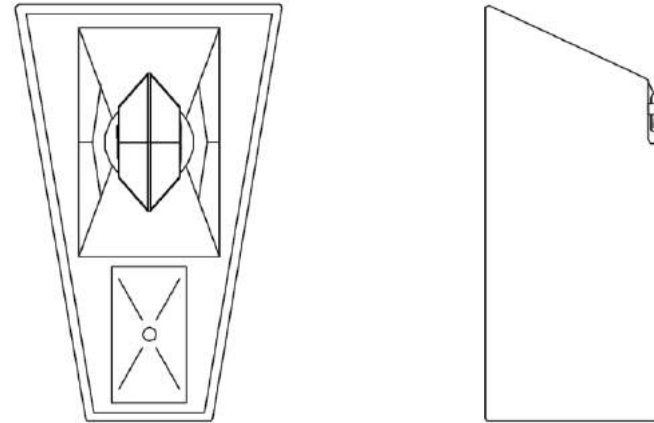


Fig 2.1-4 Resolution 4S

2.2 Unpacking and inspecting

All Funktion One products are tested and inspected thoroughly before being despatched.

- Inspect your shipment for any signs of abuse or transit damage as soon as you receive it
- If your shipment is incomplete or any of its contents are found to be damaged:
 - Inform the shipping company
 - Inform your dealer

We suggest that you keep some of the original packaging in case you have to return a unit for repair or replacement.

Funktion One Research Limited and its distributors cannot be held liable for product damaged through the use of non-approved packaging, shipping or handling methods.

2.3 Handling

Please handle your Resolution 4 system safely to avoid injury.

- Palletised, wrapped and strapped shipments should only be moved using a fork-lift truck driven by a qualified forklift truck driver
- Resolution 4T systems are supplied with wheelboards making them very easy to move around and stack safely. Wheelboards are optional for Resolution 4E systems

We recommend providing staff with suitable manual handling training before they manoeuvre a Resolution 4 system. Helpful hints are available free of charge from the UK Health and Safety Executive. See (www.hse.gov.uk/pubns/indg143.pdf).

If your Resolution 4 system is destined for an installation, ensure that it remains protected by its packaging until the installation site is ready for its installation.

3 Introduction & features

3.1 Resolution 4T, 4E, 4S & 4D

Resolution 4T touring loudspeaker system

The Resolution 4 Touring is a three-way mid-high loudspeaker enclosure perfectly suited for use in medium sized applications. Typically used two wide for 80-90 degree overall dispersion, the Resolution 4 can also be used as delay or in-fill with Resolution 5 systems (for example as side hangs in Arena systems interspersed with Resolution 18s).

This is a powerful and efficient mid-high enclosure which is designed to be operated as part of a four way system with F218, F121 or F221 bass. The sonic quality of the Resolution 4 is exceptional.

Dimensionally identical to the Resolution 5 and 18, this enclosure also shares the same patented point-source flying system making for fast and easily adjustable set up. All inter-cabinet flying hardware is built into each enclosure leaving no chains, pins or tools to lose. And the WB5 stackable wheelboard system makes Resolution 4T and 4E systems easy to truck pack and easy to move around – see www.funktion-one.com/dl/files/Wheelboard-and-Scrim_web.pdf.

The Resolution 4T system is easy to stack on top of Funktion One subwoofers using the GSS-ResT ground stack tilt strap with the GSM-Anchor. See www.funktion-one.com/products/ground-stack-systems/.



Fig 3.1-1 Resolution 4T

Resolution 4T features

- Fully horn loaded for high efficiency
- Funktion One designed Neodymium drivers
- Integrated inter-cabinet flying system
- Captive inter-cabinet/input cable in recessed cable pocket
- Identical size to Resolution 5 and 18
- Supplied with protective wheelboard
- Optional scrim for discrete appearance
- Resolution 18 bass system available (has matching profile)
- Resolution 4D downfill also available for Resolution 4T/Resolution 18 combinations flown from FG53 or FG55 flying grids

Resolution 4E - basic version for installations and medium scale events

The Resolution 4E is a great loudspeaker choice for installations and medium scale events offering exceptional sound quality.

With equal sound quality to the Resolution 4T, the Resolution 4E is supplied in a simplified 'trapezoid' enclosure without the built in flying hardware provided on the full touring version. A dedicated flying system specific to the Resolution 4E will make this product a highly attractive choice in applications where occasional rigging and de-rigging.

Like the Resolution 4T the 4E is typically used two wide for 80-90 degree overall dispersion. Dedicated accessories also enable the R4E to be flown and arrayed in fixed installations.

A single row of Resolution 4E cabinets may also be mounted on top of Funktion One subwoofers using the GSS-ResE ground stack tilt strap with the GSM-Anchor E. See www.funktion-one.com/products/ground-stack-systems/.



Fig 3.1-2 Resolution 4E

Resolution 4E features

- Choice of Ceramic or Neodymium drivers
- Simplified enclosure ideal for permanent installations
- Same sonic performance as full touring version
- Dedicated installation flying hardware available if required
- Optional Wheelboard (as supplied with the Resolution 4T)
- Single-row Ground Stack Securing system available
- Optional scrim for discrete appearance
- Optional flying system for occasional rigging/ de-rigging operations

Resolution 4S skeletal loudspeaker system

The Resolution 4S is a three-way mid-high skeletal loudspeaker, specifically designed to be cost effective by dispensing with the touring features (enclosure and flying equipment) in fixed installation applications. It offers uniform and controlled dispersion with sound quality equal to that of the enclosed versions.

The Resolution 4S is suited to a wide range of applications including demanding club and theatre venues. Also available with a passive high frequency crossover, the R4S can be bi-amplified to minimise overall system cost.

The mid-high horn section can be supplied rotated through 90° to facilitate horizontal use where ceiling height is restricted.

For weight critical applications the system can be specified with lightweight Neodymium magnets.



Fig 3.1-3 Resolution 4S

Resolution 4S features

- Lightweight minimalist design approach
- Minimal processing and no EQ required
- Equal sound quality to enclosed versions
- Funktion One designed drivers
- Optional lightweight Neodymium drivers
- Optional passive HF crossover
- Suspension points provided (May be attached vertically or horizontally depending on the required enclosure orientation)

Resolution 4D downfill loudspeaker system

The Resolution 4D downfill enclosure is designed to complete Resolution 4/Resolution 18 arrays flown from FG53 or FG55 flying grids. It offers extensive vertical dispersion providing coverage right down to the first row of seats.

Its unique tapered shape allows the rest of the cluster to be coupled closely together generating a coherent wave-front and adding a finishing touch to the spherical cluster's aesthetics.

As with other Resolution Touring enclosures, all inter-cabinet flying hardware is included.

Resolution 4D features

- Unique shape for close arraying
- Large vertical coverage
- Two-way active
- Horn loaded for high efficiency
- Funktion One designed Neodymium drivers
- Built-in flying hardware
- Captive inter-cabinet/input cable in recessed cable pocket
- Optional scrim for discrete appearance



Fig 3.1-4 Resolution 4D

3.2 Specifications

Resolution 4T, 4E & 4S systems

Driver complement:	12" cone driver 8" cone driver 1" compression driver
Frequency response:	114Hz – 18kHz
Dispersion:	50° horizontal x 25° vertical
Sensitivity:	12" 105dB for 1W at 1m 8" 108dB for 1W at 1m 1" 109dB for 1W at 1m
Nominal impedance:	12" 8 ohms 8" 16 ohms 1" 16 ohms
Power ratings:	12" 300W AES, 1,200W peak (8 ohms) 8" 200W AES, 800W peak (16 ohms) 1" 50W AES, 200W peak (16 ohms)
Voltage ratings:	12" 48vrms long-term, 96v peak (8 ohms) 8" 56vrms long-term, 112v peak (16 ohms) 1" 28vrms, 56v peak (16 ohms)
Calculated single-cabinet maximum spl at 1m:*	
*See Appendix C	Low-mid 129dB spl rms, 135dB spl peak High-mid 131dB spl rms, 137dB spl peak High 125dB spl rms, 131dB spl peak

Recommended amplifier power using suitable limiters:

Section	Power into 16 ohms	Power into 8 ohms	Power into 4 ohms
12" Low-mid	-	300 - 1,200W	600 - 2,400W
8" High-mid	200 - 800W	400 - 1,600W	800 - 3,200W
1" High	50 - 200W	100 - 400W	200 - 800W

Drivers & connectors:	Resolution 4T:	Neodymium Drivers, EP6 connector panel & captive link lead in cable recess
	Resolution 4E-CP:	Ceramic drivers, passive HF crossover, NL4 panel sockets
	Resolution 4E-C:	Ceramic drivers, active, EP6 panel sockets
	Resolution 4E-NP:	Neodymium drivers, passive HF crossover, NL4 panel sockets
	Resolution 4E-N:	Neodymium drivers, active, EP6 panel sockets
	Resolution 4S:	Ceramic drivers, active, industrial sprung terminals (Optional neodymium drivers, optional passive HF crossover)
Fittings:	Resolution 4T:	Integral inter-cabinet flying system (Toggle pins at the top, spring-hinged tabs at the bottom, Biscomatic tilt adjuster on back, tilt strap catches top & bottom)
	Resolution 4E:	M10 fixing points (top, bottom, sides & back)
	Resolution 4S:	Lifting points - top & back (May be attached vertically or horizontally as required)
Weight:	Resolution 4T:	46kg (101lb)
	Resolution 4E-CP:	53kg (117lb)
	Resolution 4E-C:	53kg (117lb)
	Resolution 4E-NP:	47kg (104lb)
	Resolution 4E-N:	47kg (104lb)
	Resolution 4S:	38kg (84lb) Ceramic 31kg (71lb) Neodymium

Resolution 4D downfill system

Driver complement: 8" cone driver, 1" compression driver

Frequency response: 445Hz – 18kHz

Dispersion: 25° horizontal x 50° vertical

Sensitivity: 8" 108dB for 1W at 1m, 1" 109dB for 1W at 1m

Nominal impedance: 8" 16 ohms, 1" 16 ohms

Power ratings: 8" 200W AES, 800W peak (16 ohms), 1" 50W AES, 200W peak (16 ohms)

Voltage ratings: 8" 56vrms, 112v peak (16 ohms), 1" 28vrms, 56v peak (16 ohms)

Max peak voltage: 8 (into 16 ohms), 1" 56vrms (into 16 ohms)

Calculated single-cabinet maximum spl at 1m:*

***See Appendix C**

High-mid	131dB spl rms, 137dB spl peak
High	126dB spl rms, 132dB spl peak

Recommended amplifier power using suitable limiters:

Section	Power into 16 ohms	Power into 8 ohms	Power into 4 ohms
8" High-mid	200 - 800W	400 - 1,600W	800 - 3,200W
1" High	50 - 200W	100 - 400W	200 - 800W

Connectors: EP6 panel & captive lead in cable recess

Fittings: Integral inter-cabinet flying system

Weight: 20kg (44lb)

3.3 Dimensions

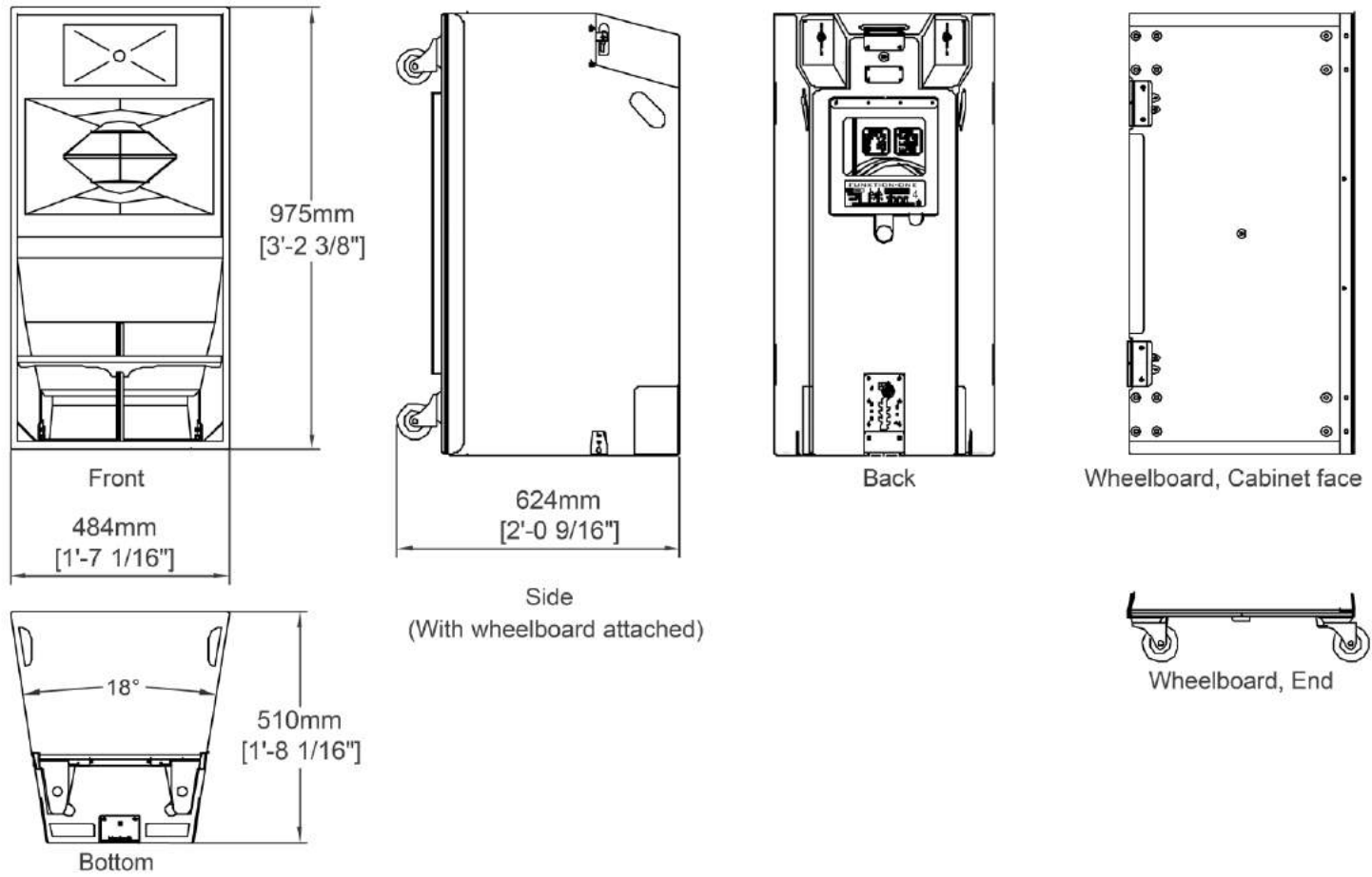


Fig 3.3-1 Resolution 4T dimensions – mm (ft & inches)

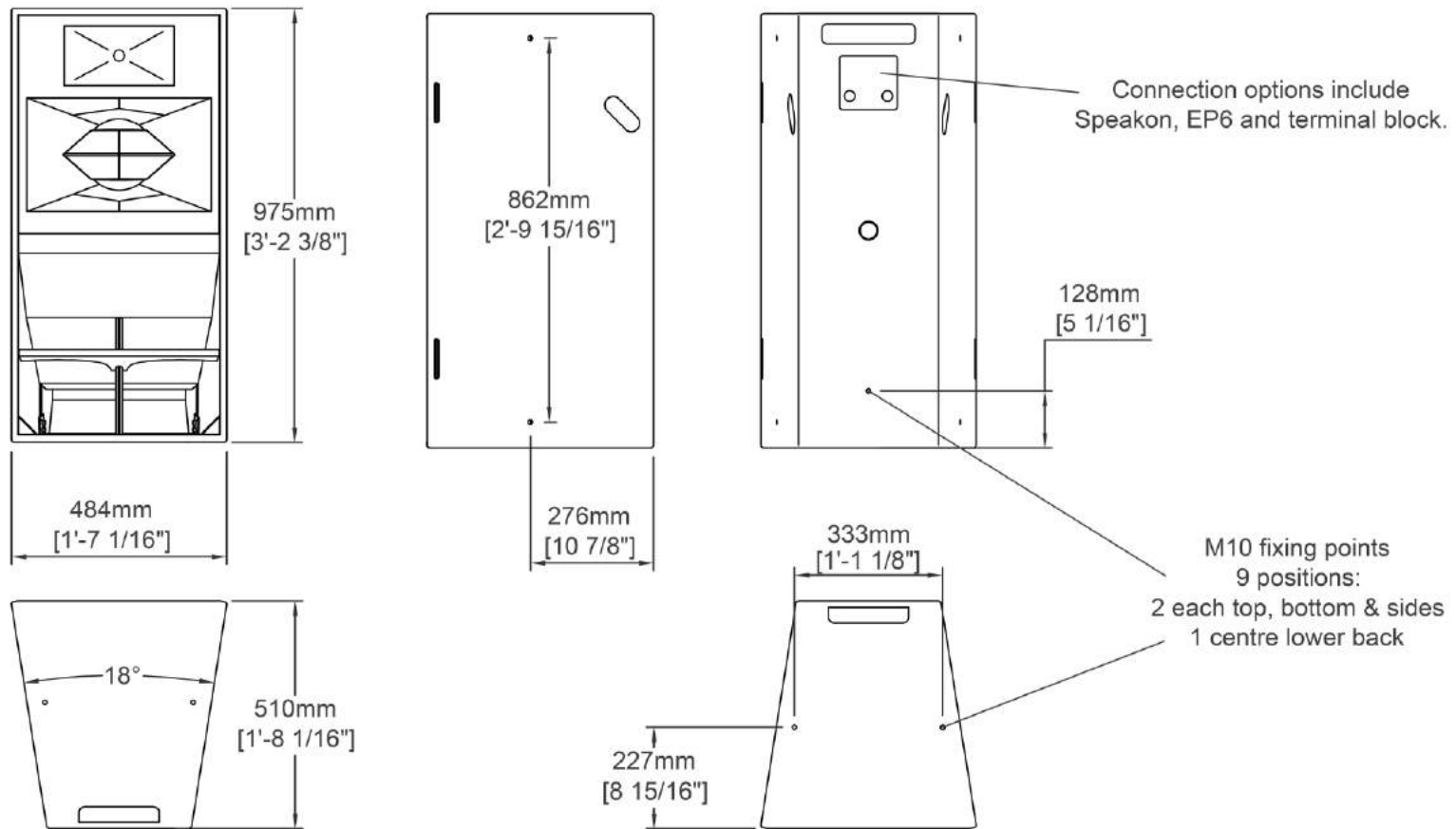


Fig 3.3-2 Resolution 4E dimensions – mm (ft & inches)

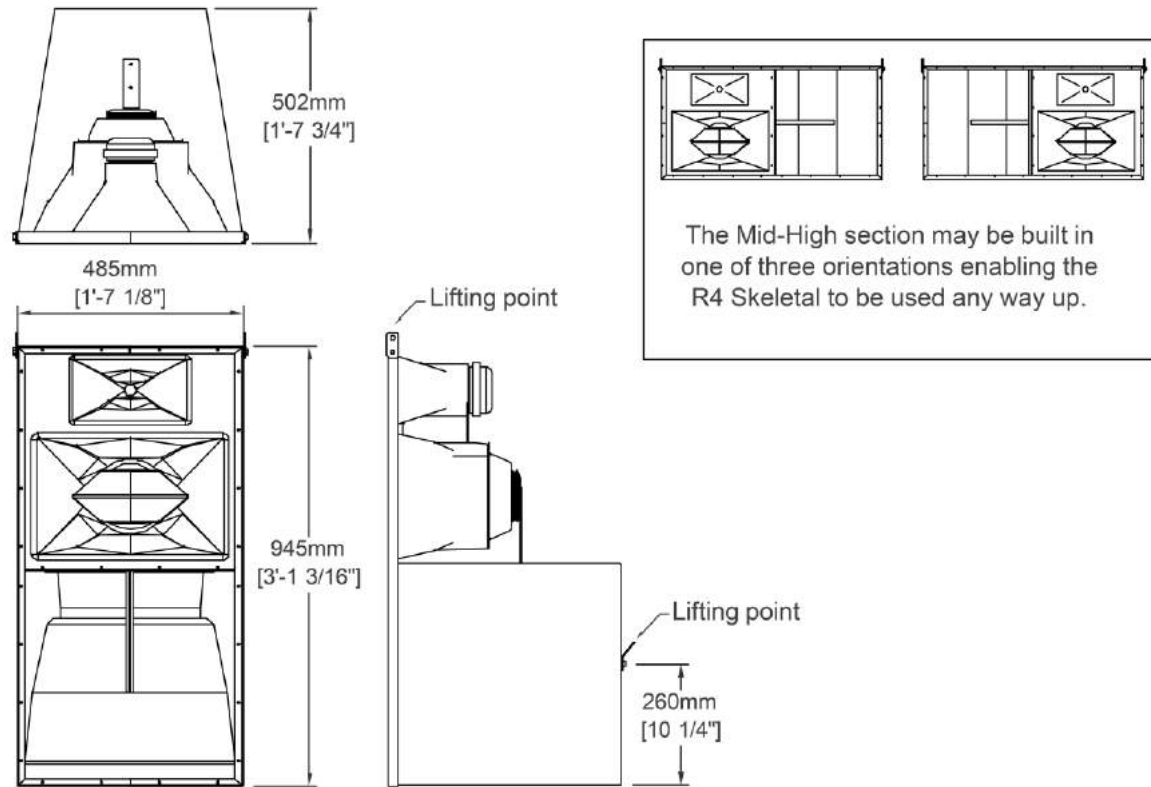


Fig 3.3-3 Resolution 4S dimensions – mm (ft & inches)

The lifting points are shown for vertical orientation (main drawing) and horizontal orientation (inset)

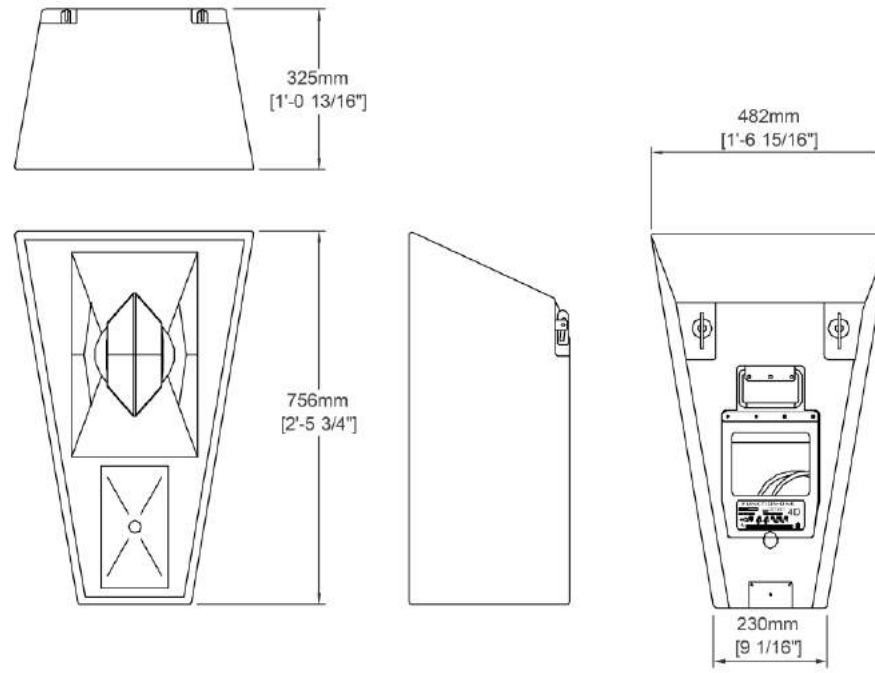


Fig 3.3-4 Resolution 4D dimensions – mm (ft & inches)

4 Flying and stacking

4.1 Mechanical safety



Safety is everyone's business!

However tight the deadline, always ensure that rigging and installation work is completed by fully qualified and experienced personnel wearing safety boots and hard hats as necessary.

Use only Funktion One manufactured or approved flying and stacking accessories.

4.2 Resolution 4/5 flying system introduction

Overview

Resolution 4, 5 and 18 touring enclosures are dimensionally identical to each other and share all necessary inter-cabinet flying hardware.

A three wide, two deep Resolution 4 array – plus downfills - weighs less than ½ton and flies from a single point.

The intuitive simplicity with which the cluster clips together combined with the enclosures' extreme lightness and small size makes working with the system a liberating experience from handling and rigging perspectives, as endorsed by enthusiastic users worldwide.

Resolution 4 point source arrays are built as multiple columns hung on the spokes of purpose-built grids. The grid spokes are set for 40 - 45° horizontal splay angles and are spaced to allow room for vertically curved arrays.

The integral cabinet fittings are also useful for ground-stacking. Enclosures can easily be secured, linked and aimed.



Quick deployment

An arena cluster can usually be assembled and flown by just two people in about 20 minutes.

The hardware comes built in to the Resolution 4T and 4D enclosures, with no bits to lose and no tools required. The cluster is solid and it is straightforward to aim the loudspeakers where they are required.

Inter-cabinet splay angles may be set accurately, with repeatability assured, thanks to the novel "Biscomatic" tilt adjustment mechanism built into the back of the Resolution 4T touring cabinets (*see next page*).

Each spring-hinged flying tab forms an inter-cabinet pivot making any re-aiming very easy. Two people can re-set the vertical angles without lowering the cluster to the ground.

Note

The Resolution 4D downfill cabinet has narrower horizontal coverage than the Resolution 4T but may be used beneath Resolution 4T/Resolution 18 combinations flown from FG53 or FG55 flying grids. Its width and spring-hinged flying tabs are fully compatible for easy integration.

See array plan views later.

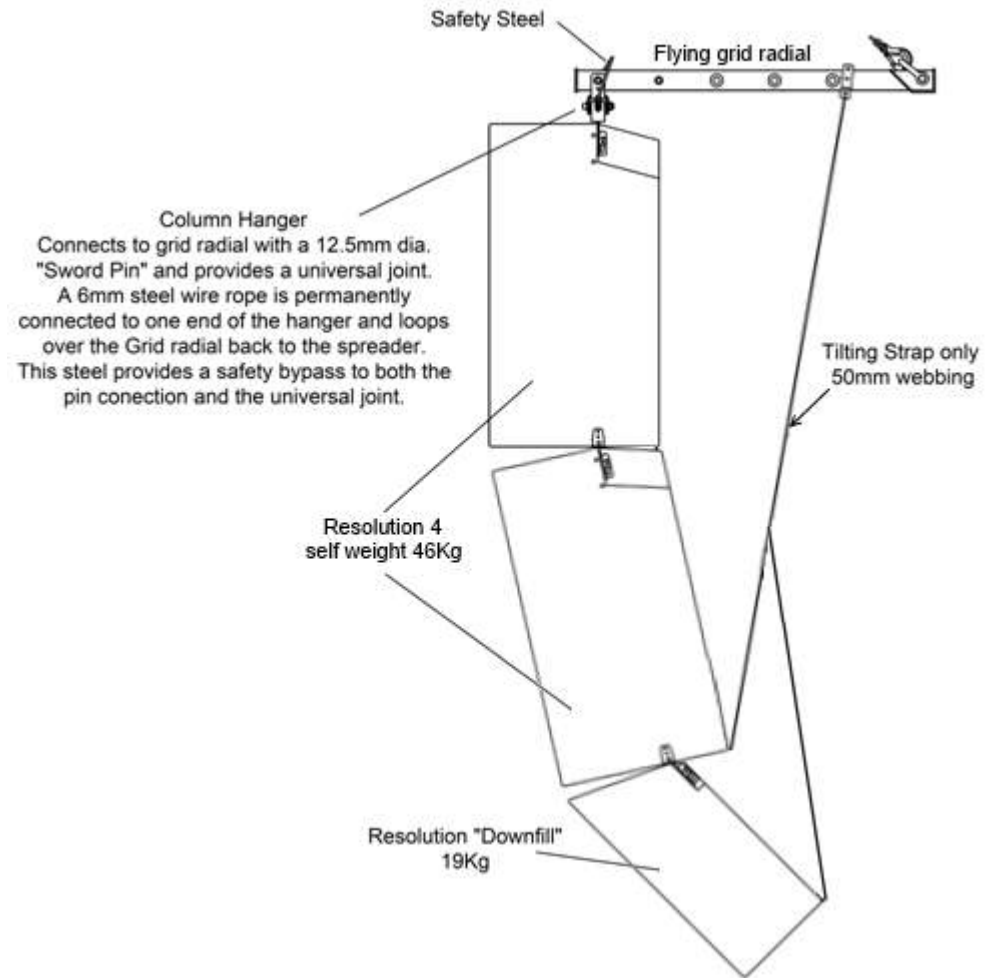


Fig 4.2-1 Flying system

4.3 Flying facilities vs loudspeaker type

Resolution 4T touring loudspeaker system

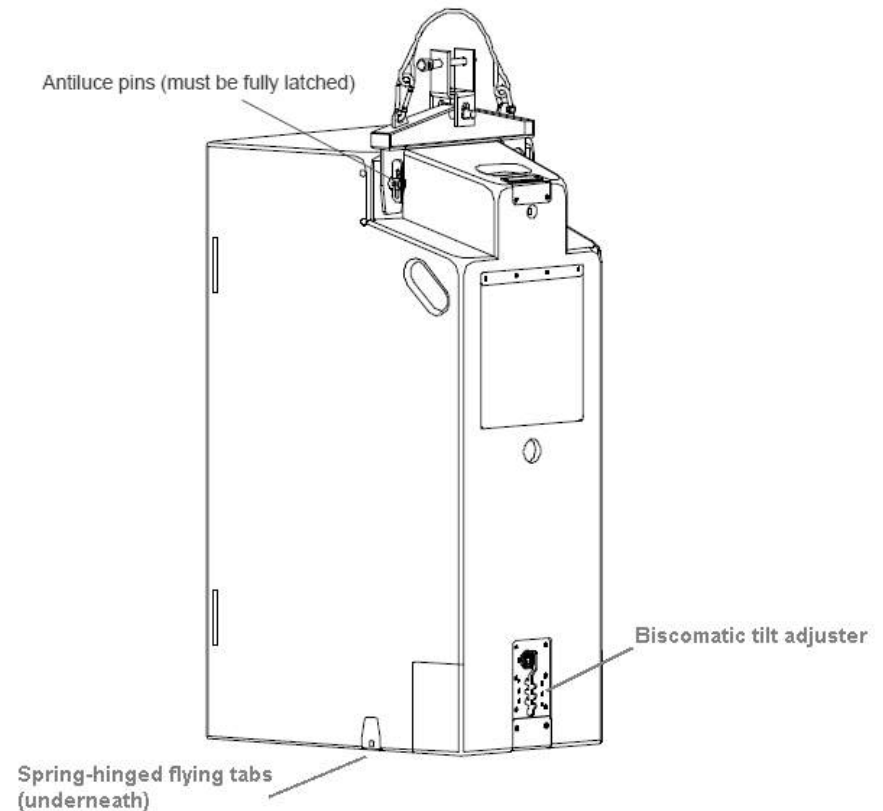
Resolution 4T integral rigging

- Antiluce (toggle) pins - at the top
- Biscomatic tilt adjustment mechanism - at the bottom rear
- Spring-hinged flying tabs (not visible) - at the bottom sides

Funktion One approved flying parts.

- Quick deployment integral flying system
- CH5 column hangers
- Multi-column FG series flying grids
- BR5 series chain bridle and bow shackles for flying grid
- H505 chain hoist for levelling grid
- TS5 flying system 4m tilt strap with down-fill strap
- TS5-S flying system 2m tilt strap - no down-fill strap

See **Section 4.4** for further details and user guidance



**Fig 4.3-1 Resolution 4T integral flying system
(CH5 column hanger complete and safety steel attached)**

Resolution 4E - basic version for installations and medium scale events

Integral rigging

- Integral M10 fixing points

Funktion One approved flying parts.

- Optional flying system available for infrequent (e.g. seasonal) rigging/de-rigging

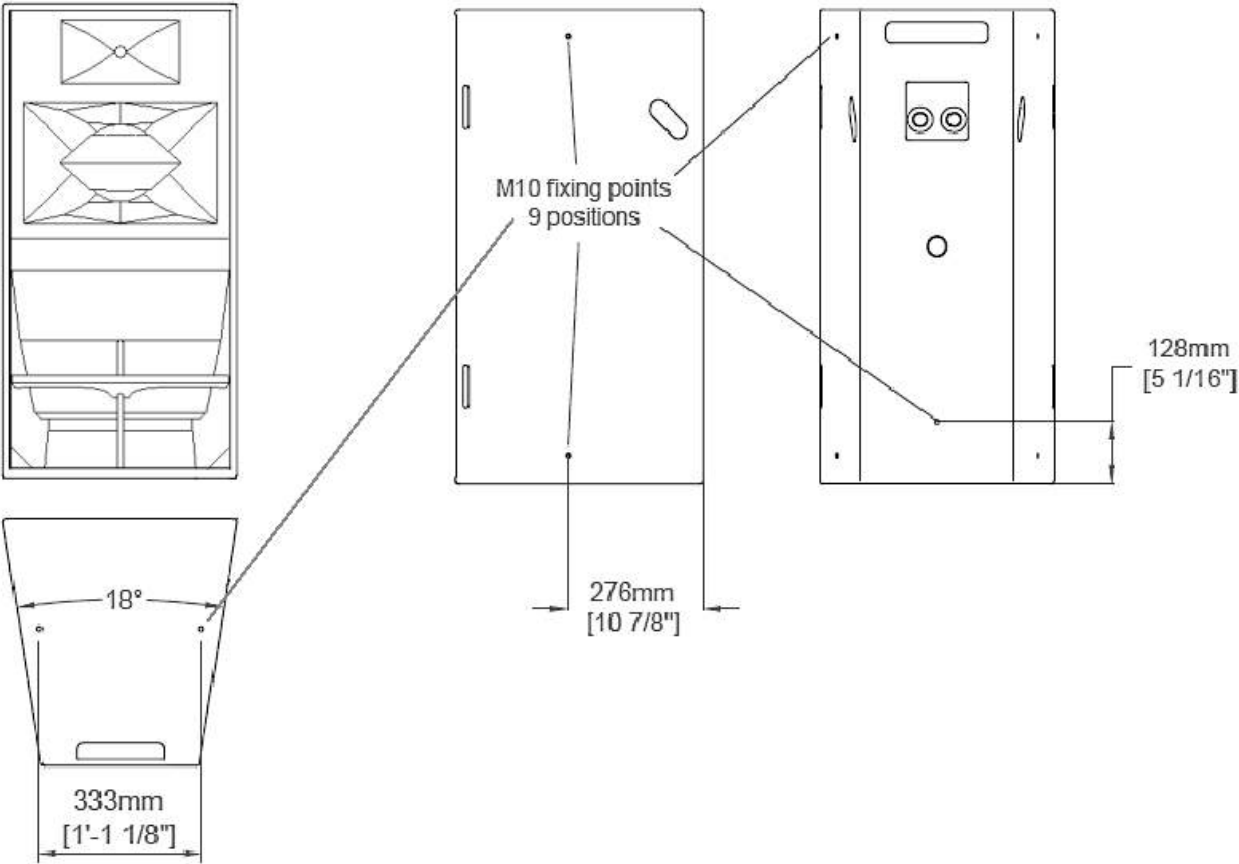


Fig 4.3-2 Resolution 4E fixing points

Resolution 4S skeletal loudspeaker system

Integral rigging

- Integral lifting points (May be attached vertically or horizontally depending on the required enclosure orientation)

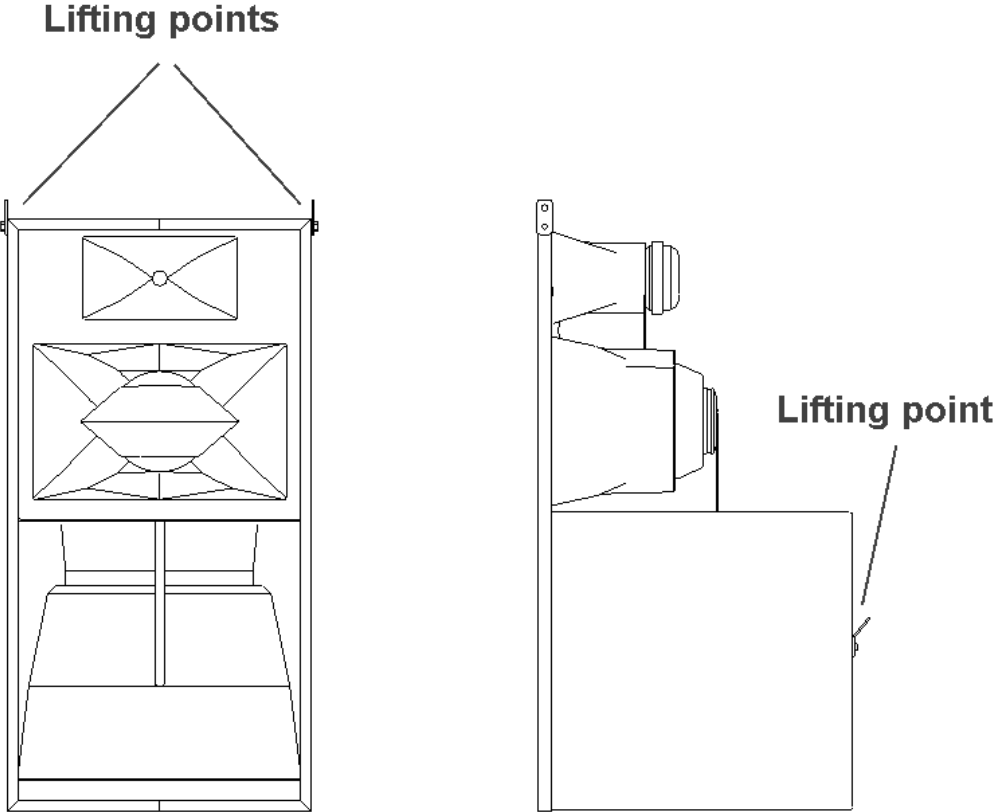


Fig 4.3-3 Resolution 4S lifting points

Resolution 4D downfill system

Integral rigging

- Quick deployment integral flying system

Funktion One approved flying parts.

- Multi-column FG series flying grids available
- BR5 series chain bridle and bow shackles for flying grid
- H505 chain hoist for levelling grid
- CH5 column hangers available
- TS5 flying system tilt strap available

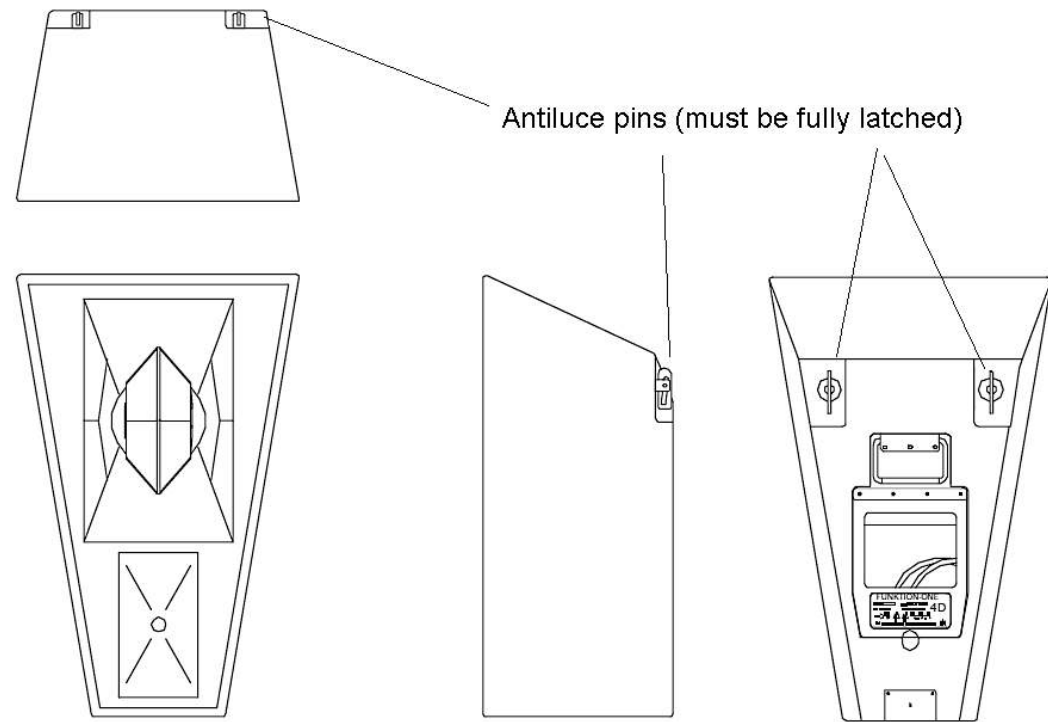


Fig 4.3-4 Resolution 4D integral rigging system

4.4 Main touring system flying components and typical grid layouts

Column hanger - for Resolution 4T touring system

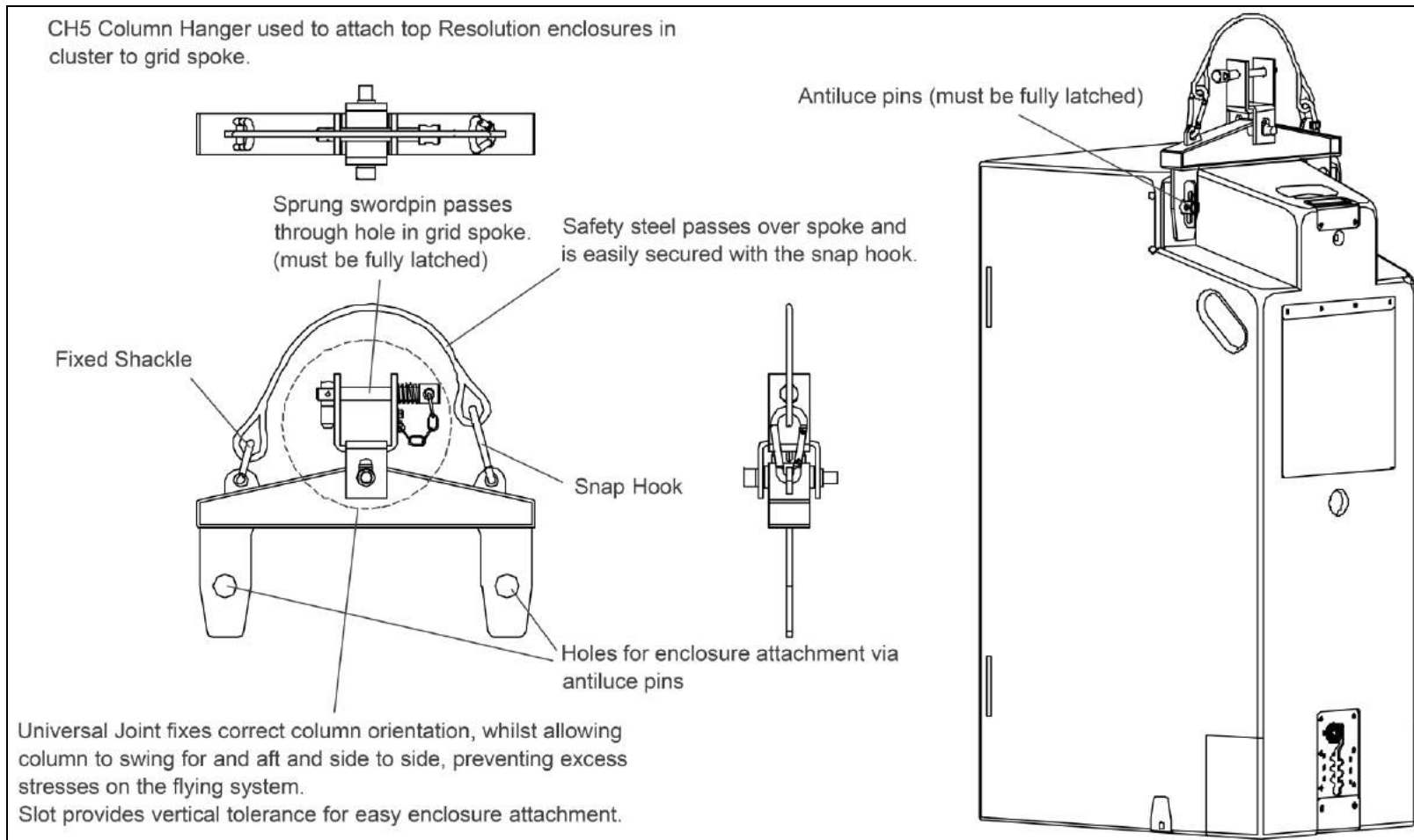


Fig 4.4-1 Column hanger details (left) - fitted to Resolution 4T enclosure (right)

FG42 (2-way) and FG43 (3-way) flying grids (FG43 shown)

FG series flying grids cater for a variety of Resolution 4 array widths, typically 1, 2 or 3 columns wide, set to horizontal splay angles of 40° (FG43, FG53 & FG55) or 45° (FG42). See plan views later.

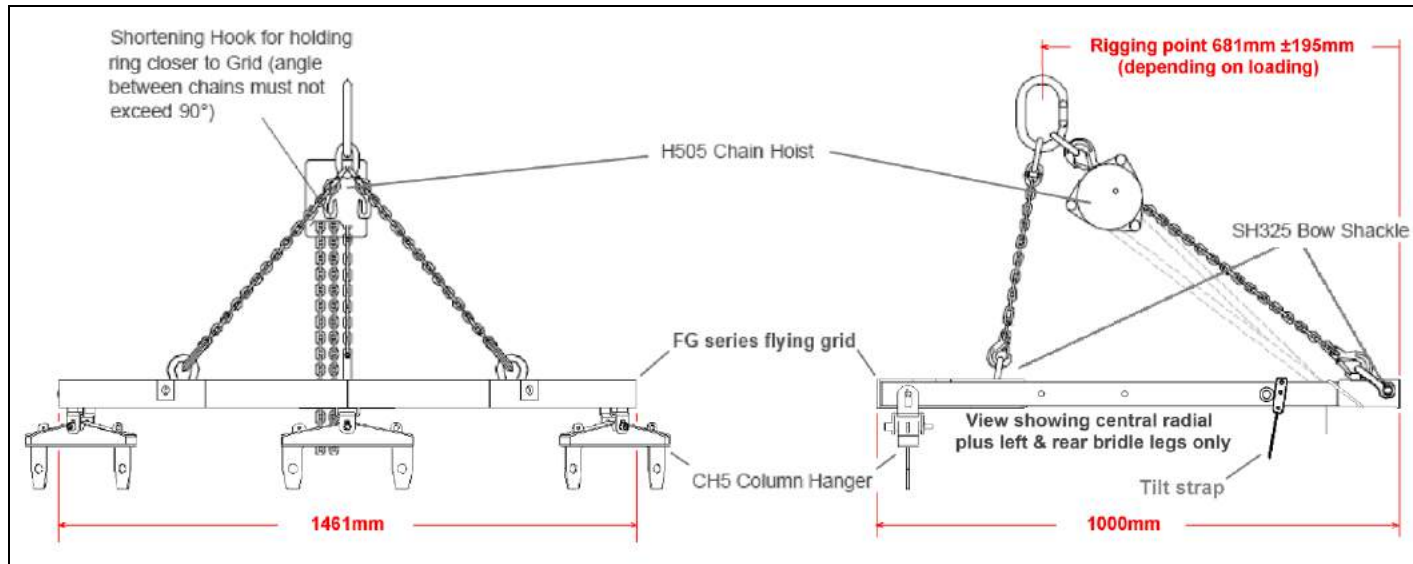


Fig 4.4-2 FG43 3-wide flying grid with BR53 bridle and H505 chain hoist attached via SH325 shackles – not to scale
(Note tilt strap fits behind tilt strap restraining point - see central radial view)

Resolution 4 grids

FG42 2-way flying grid for 2-wide Resolution 4 arrays

FG42 with integral chain bridle - 19Kg

2 column hangers & tilt-straps - 10Kg

Total flying weight without Loudspeakers - 29Kg

FG43 3-way flying grid for 2 or 3-wide Resolution 4 arrays

FG43 - 35Kg, 5 shackles - 3.25Kg, chain bridle (complete with chain hoist) - 11Kg

3 column hangers & tilt-straps - 15Kg

Total flying weight without Loudspeakers - 64.2Kg

2 to 3-way system weight (excluding cables)

To calculate system weight, just add: 46Kg per R4, 41Kg per R18 and 20Kg per R4D (downfill)

FG53 and FG55 flying grids may also be used for Resolution 4 arrays (FG55 shown)

Resolution 4 systems may be flown with 40° horizontal splay angles using FG53 or FG55 grids (with 20° spoke splay) either by leaving the intermediate spokes unused - or by using the intermediate spokes to fly Resolution 18 bass cabinets. See plan views later.

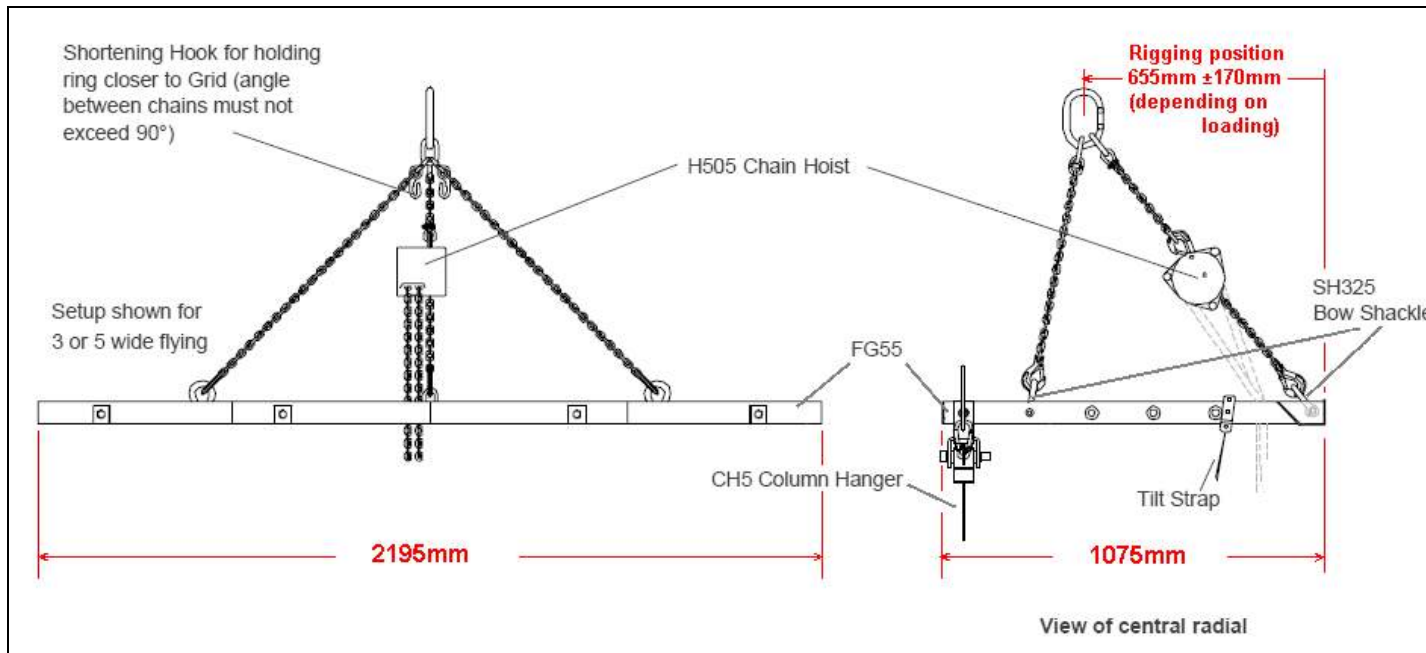


Fig 4.4-3 FG55 5-wide grid scheme with BR5 bridle, and H505 chain hoist attached via SH325 shackles – not to scale
 (Note tilt strap fits behind tilt strap restraining point - see central radial view)

FG53 3-way flying grid for a 2-wide Resolution 4 arrays plus an optional central Resolution 18 bass column if required

FG53 Grid and 5 shackles - 31.25kg
 Chain bridle + rear chain hoist - 11kg
 3 column hangers & tilt straps - 10kg

Total flying weight for a 3-way array without loudspeakers - 57.25kg

FG55 5-way flying grid for a 3-wide Resolution 4 arrays plus 2 optional interspersed Res 18 bass columns if required

FG55 Grid and 5 shackles - 54.25kg
 Chan bridle (c/w rear leg hoist) - 11kg
 5 column hangers & tilt straps - 25kg

Total flying weight for a 5-way array without loudspeakers - 90.25k



Do not overload the flying system!

A maximum of **four** Resolution 4 cabinets - plus an additional downfill - may be flown from each column hanger

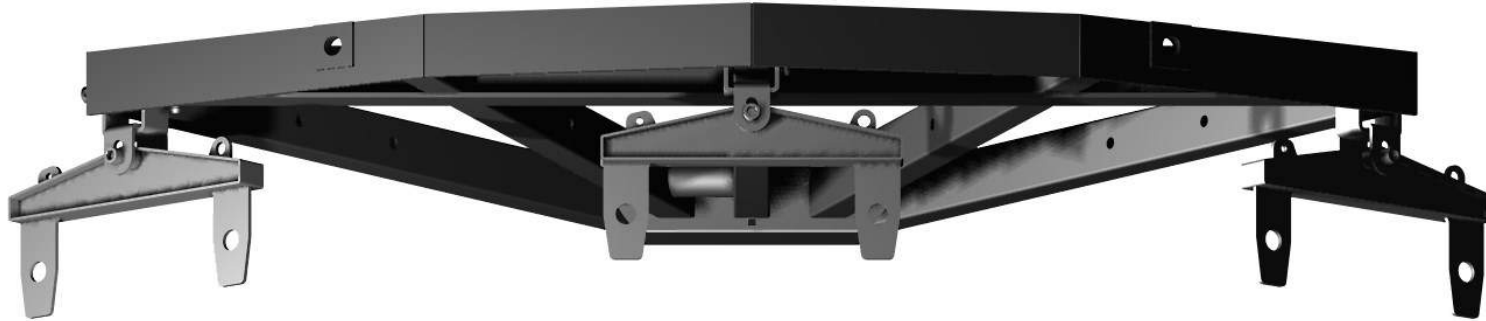


Fig 4.4-4 FG43 grid with column hangers on outer points - for 2 or 3 cabinets per column (+ downfill if required) - or if more down-tilt is required (Bridles, safeties etc not shown)



Fig 4.4-5 FG43 grid with column hangers on middle points - for just 1 or 2 cabinets per column - or if more up-tilt is required (Bridles, safeties etc not shown)



Fig 4.4-6 FG43 grid with top row in place - on outer hanger points for 2 or 3 cabinets per column or when more down-tilt is required (Bridles, safeties etc not shown)

Resolution 4T cabinets with their column hangers on the outer hanger points in preparation for a 2 or 3-deep cluster or if an overall down-tilt is required. Placing column hangers in this forward (outer) position helps counteract the tendency for deep, curved columns to tilt upwards about their centre of gravity.



**Fig 4.4-7 FG43 grid with top row in place - on inner hanger points for just 1 or 2 cabinets per column or when more up-tilt is required
(Bridles, safeties etc not shown)**

Resolution 4T cabinets with their column hangers on the middle hanger points in preparation for a 1 or 2-deep cluster or if an overall up-tilt is required. Placing column hangers in position further back helps counteract the tendency for shallow columns to tilt downwards about their centre of gravity.

2-wide Resolution 4 array using FG42 grid and the outer hanger points

- Column hanger points
- Tilt straps fit behind these points

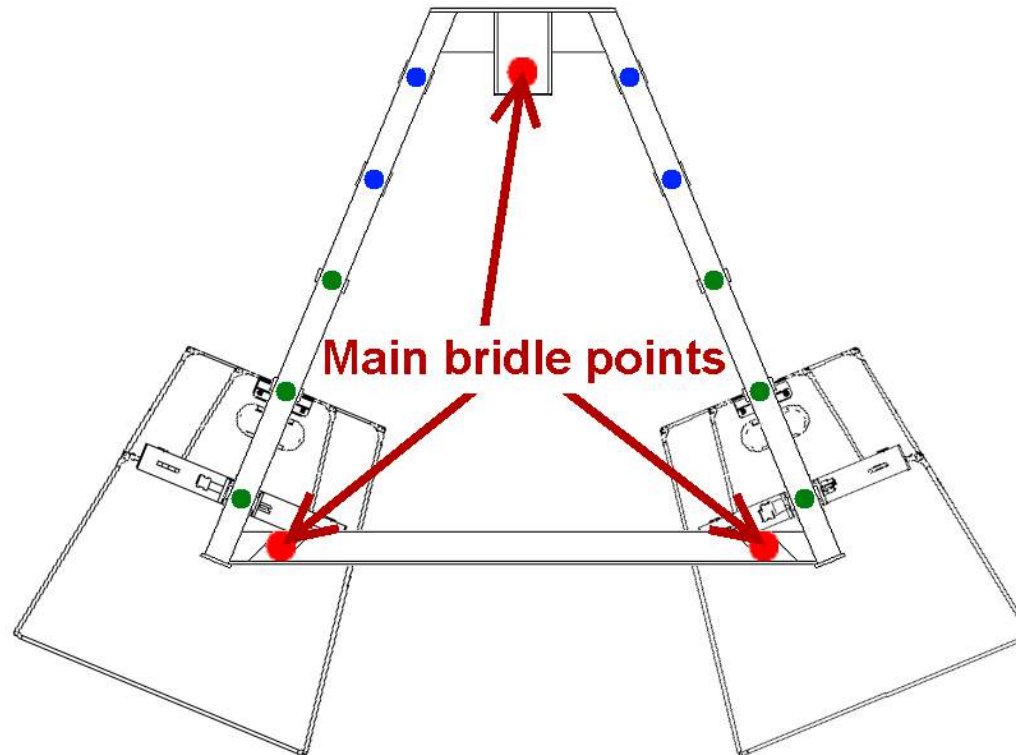


Fig 4.4-8 FG42 grid showing main bridle points for a 2-wide array. (Outer hanger positions for 3 cabinets per column - or for more down-tilt)
Use steel wire rope slings (with PVC protective tubing) near the main bridle points as safety back-ups

Note that the FG42 grid has a 45° inter-cabinet angle (to cater for high tilt operations) and it is supplied complete with an integral 3-legged bridle.

2-wide Resolution 4 array using FG42 grid and the middle hanger points

- Column hanger points
- Tilt straps fit behind these points

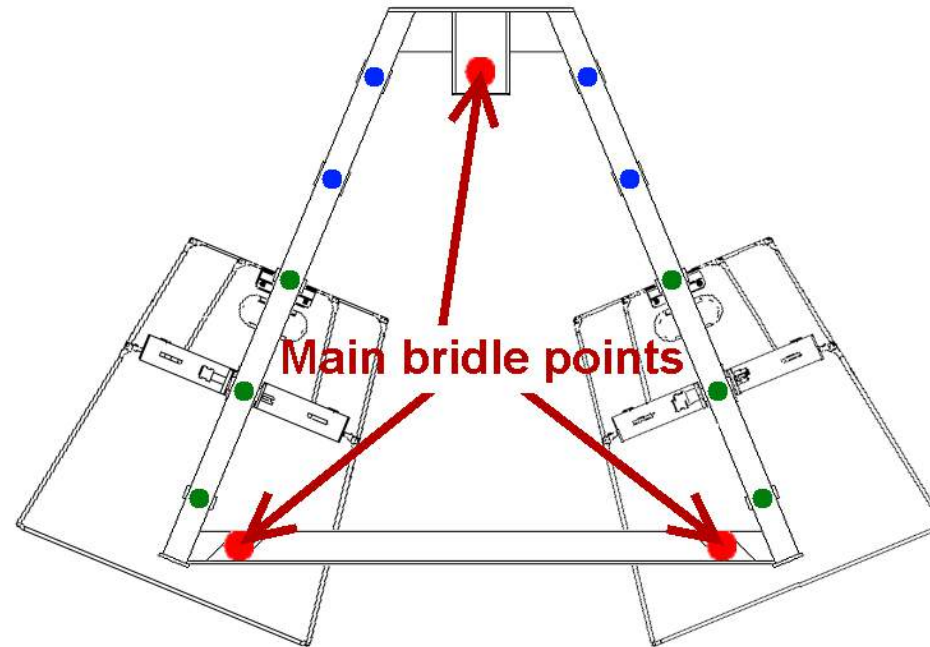


Fig 4.4-9 FG42 grid showing main bridle points for a 2-wide array. (Middle hanger positions for just 1 or 2 cabinets per column - or for more up-tilt)
Use steel wire rope slings (with PVC protective tubing) near the main bridle points as safety back-ups

Again, note that the FG42 grid has a 45° inter-cabinet angle and it is supplied complete with an integral 3-legged bridle.

2-wide Resolution 4 array using FG43 grid
On outer hanger points

- Column hanger points
- Tilt straps fit behind these points

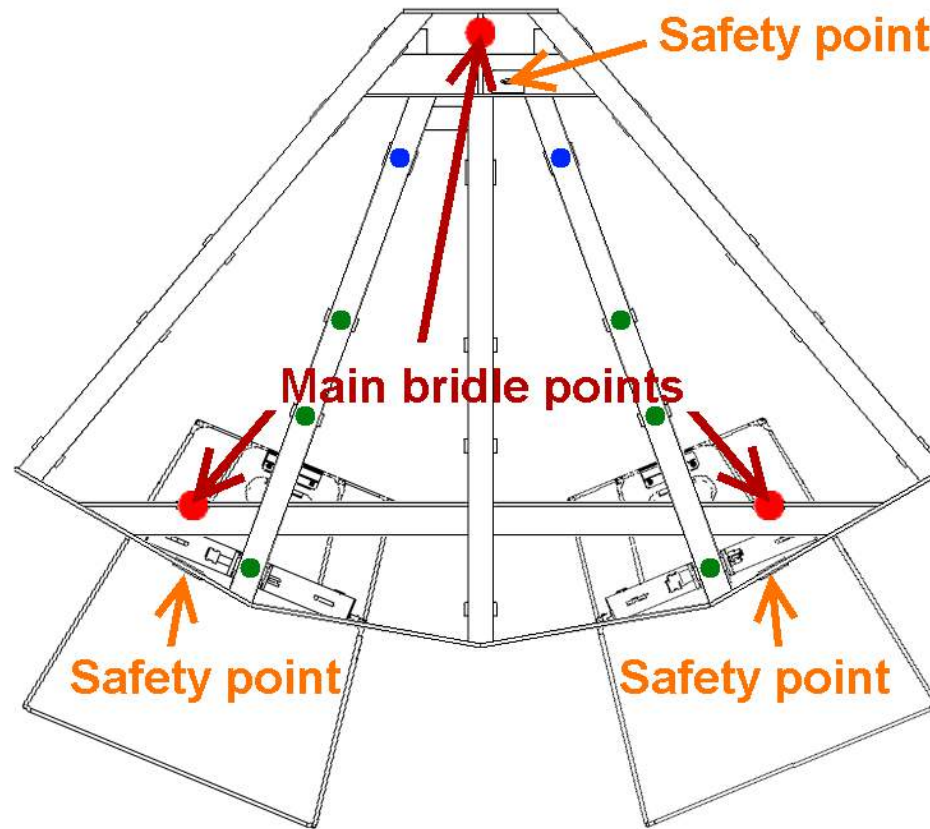


Fig 4.4-10 FG43 grid showing main bridle points and safety points for a 2-wide array
Outer hanger positions for 2 or 3 cabinets per column (+ downfill if required) - or for more down-tilt

2-wide Resolution 4 array using FG43 grid
On middle hanger points

- Column hanger points
- Tilt straps fit behind these points

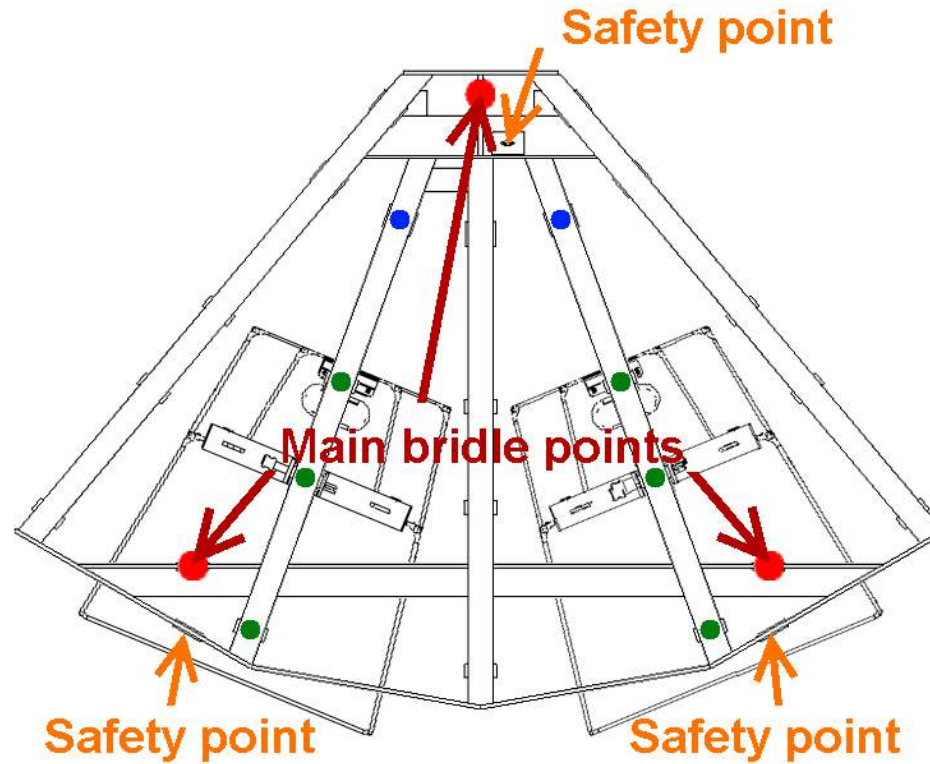


Fig 4.4-11 FG43 grid showing main bridle points and safety points for a 2-wide array
Middle hanger positions for 1 or 2 cabinets per column - or for more up-tilt

3-wide Resolution 4 array using FG43 grid
On outer hanger points

- Column hanger points
- Tilt straps fit behind these points

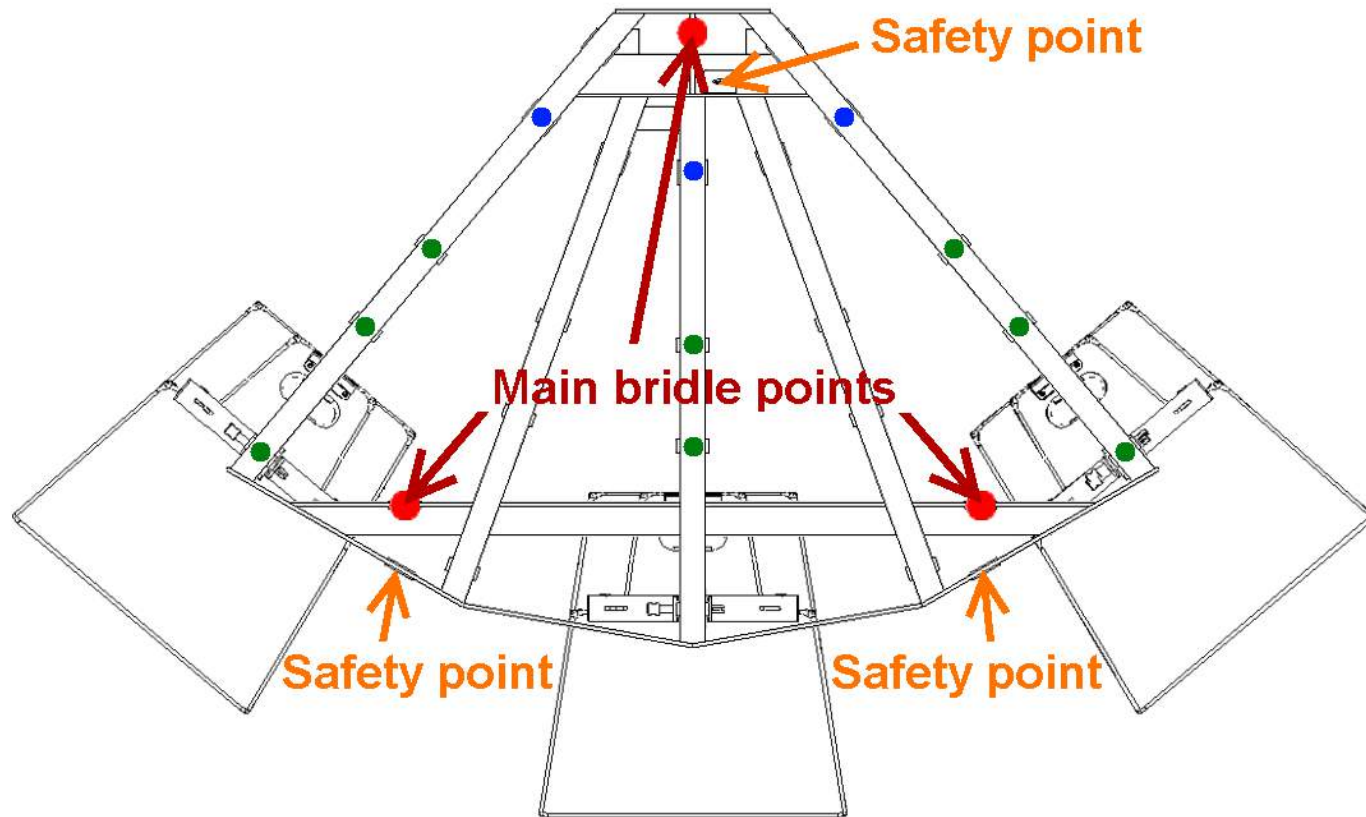


Fig 4.4-12 FG43 grid showing main bridle points and safety points for a 3-wide array
Outer hanger positions for 2 or 3 cabinets per column - or for more down-tilt

3-wide Resolution 4 array using FG43 grid
On middle hanger points

- Column hanger points
- Tilt straps fit behind these points

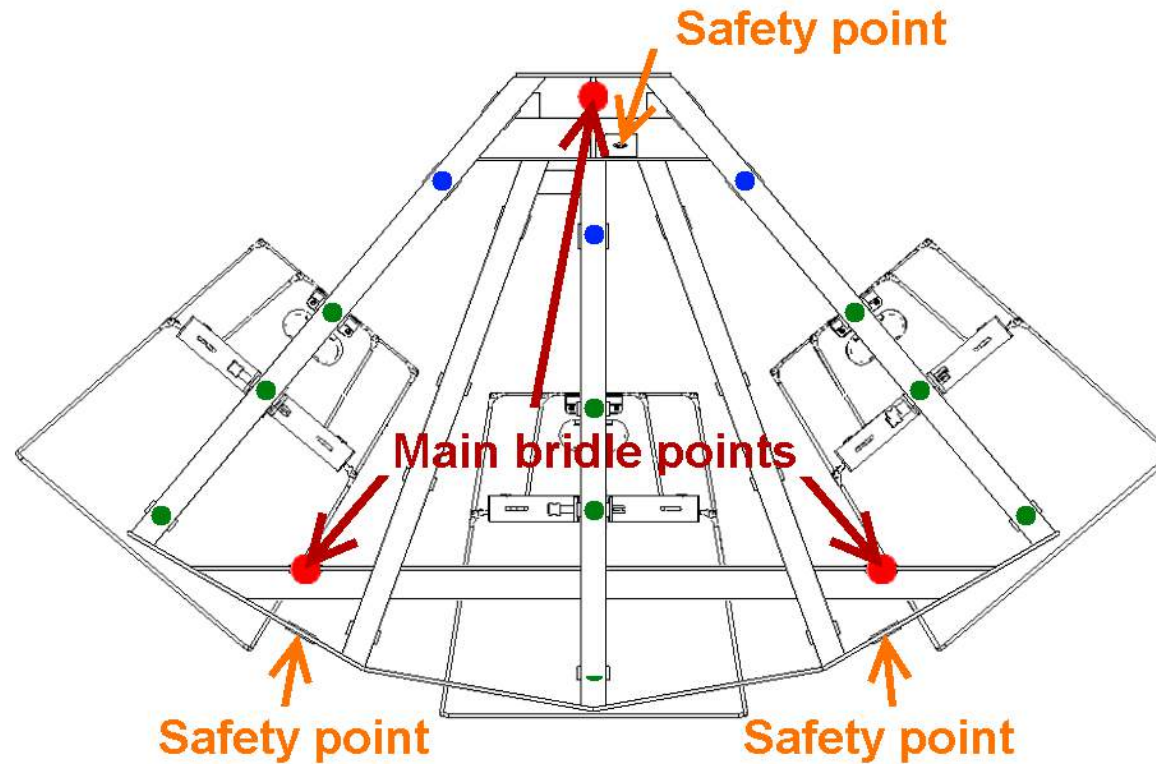


Fig 4.4-13 FG43 grid showing main bridle points and safety points for a 3-wide array
Middle hanger positions for 1 or 2 cabinets per column - or for more up-tilt

Typical Resolution 4 layout using an FG53 grid
 2 x Resolution 4 (plus an optional central Resolution 18)

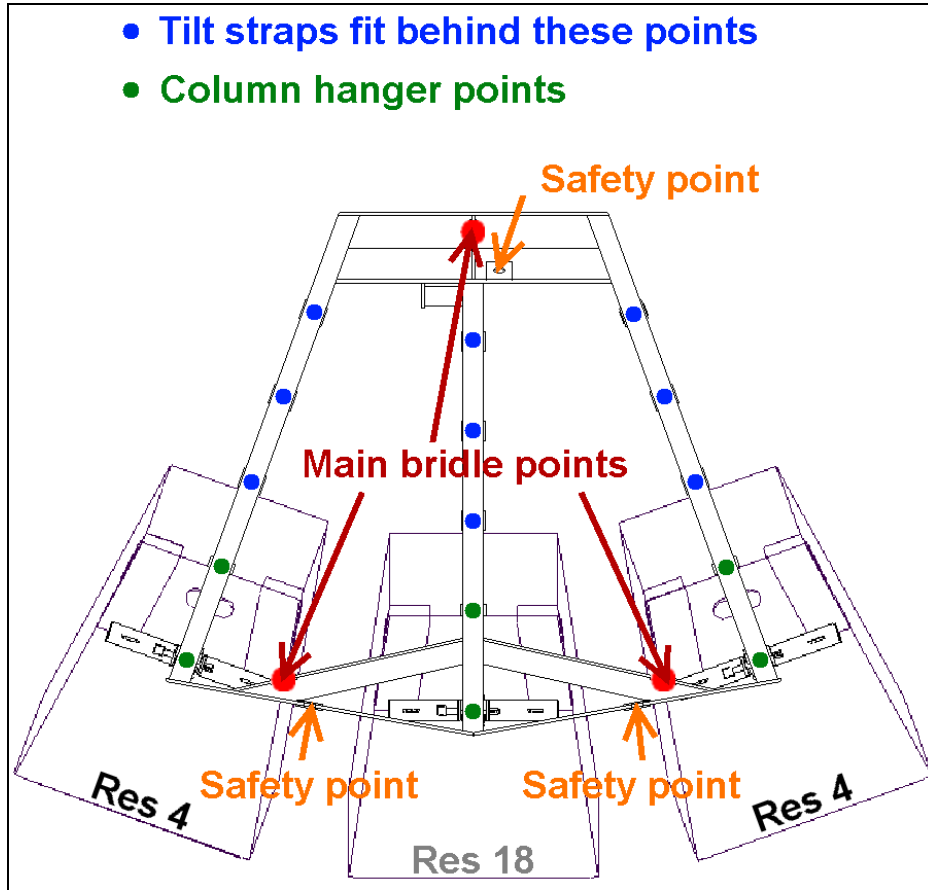


Fig 4.4-14 FG53 grid with column hanger, tilt strap, bridle & safety points
 Outer positions for columns of 2 or 3 or more cabinets - or for more down-tilt

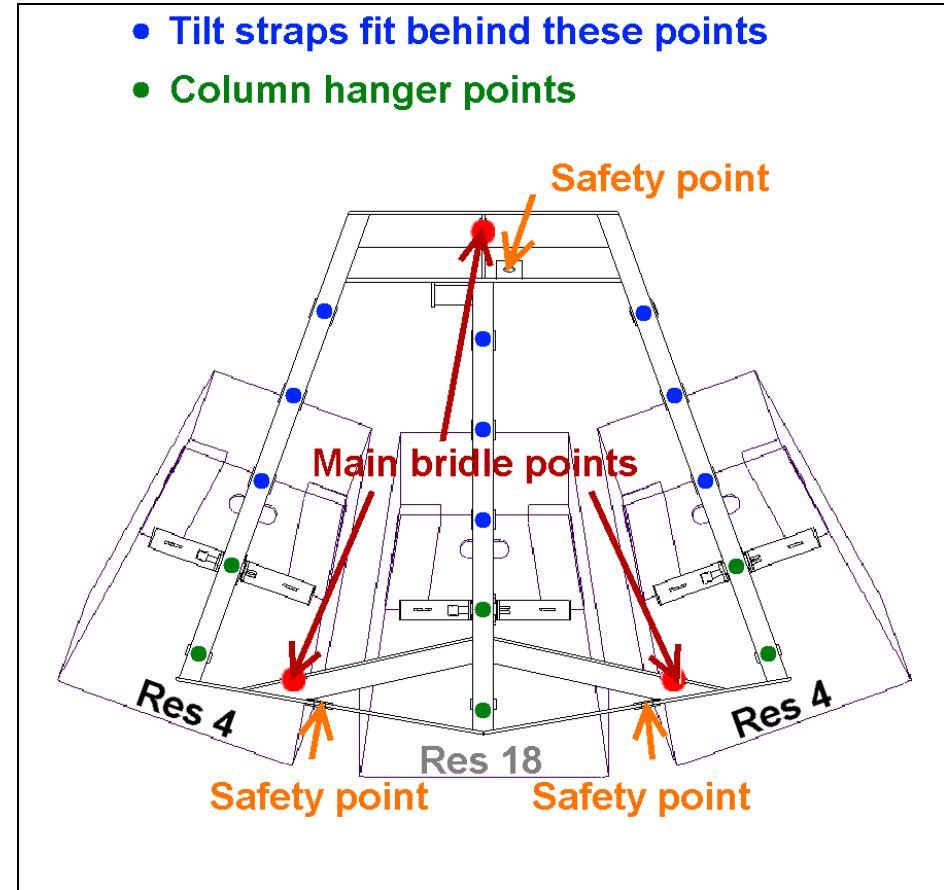


Fig 4.4-15 FG53 grid with column hanger, tilt strap, bridle & safety points
 Inner positions for columns of just 1 or 2 cabinets - or for more up-tilt

Typical Resolution 4 layout using an FG55 grid
3 x Resolution 4 (plus optional 2 x Resolution 18) on outer hanger points

- Column hanger points
- Tilt straps fit behind these points

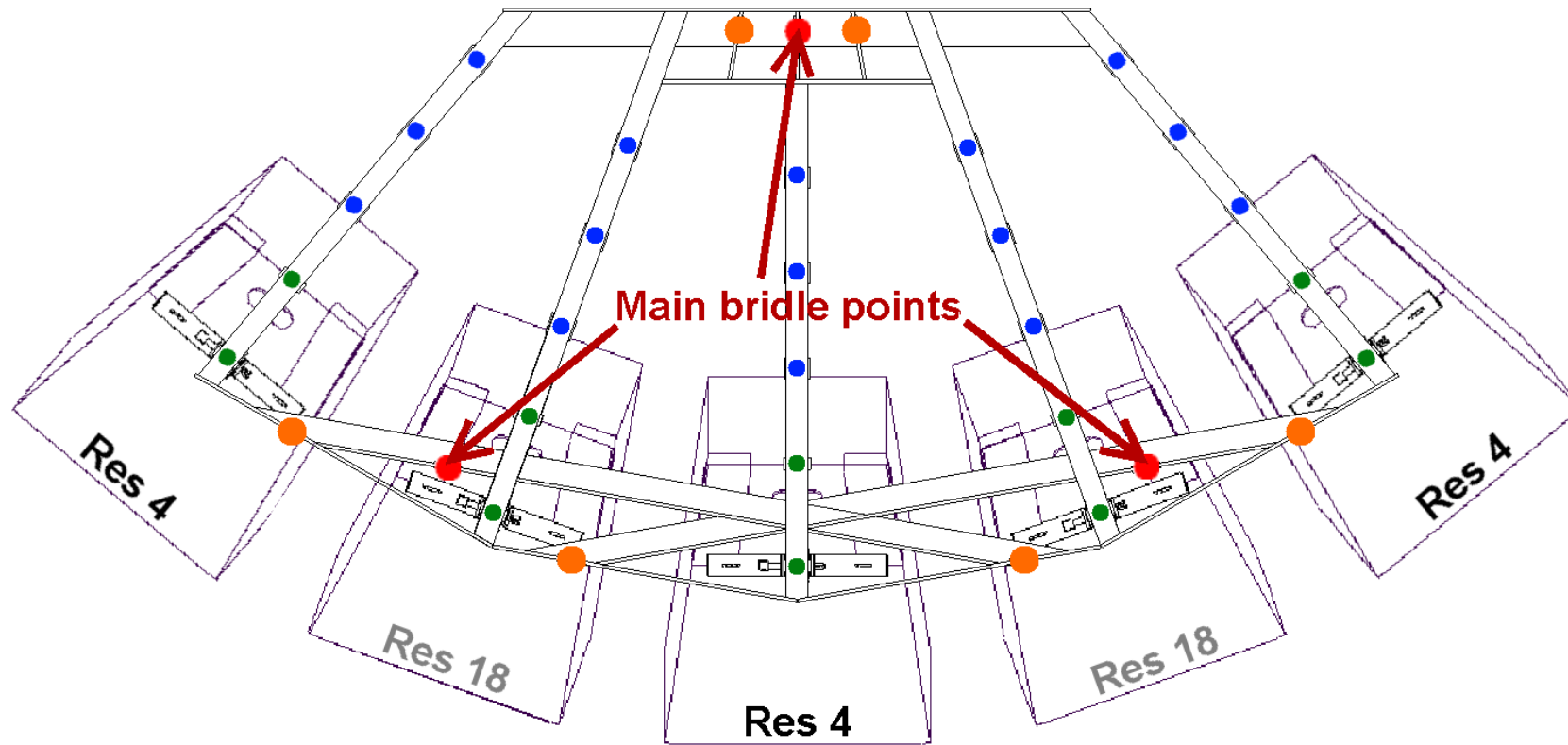


Fig 4.4-16 FG55 grid showing main bridle points for a 3 x Resolution 4 columns (plus optional 2 x Resolution 18 columns as shown)
Outer hanger positions for 2 or 3 cabinets per column - or for more down-tilt
Unused bridle points (indicated with orange dots) may be used for safeties

Typical Resolution 4 layout using an FG55 grid
3 x Resolution 4 (plus optional 2 x Resolution 18) on inner hanger points

- Column hanger points
- Tilt straps fit behind these points

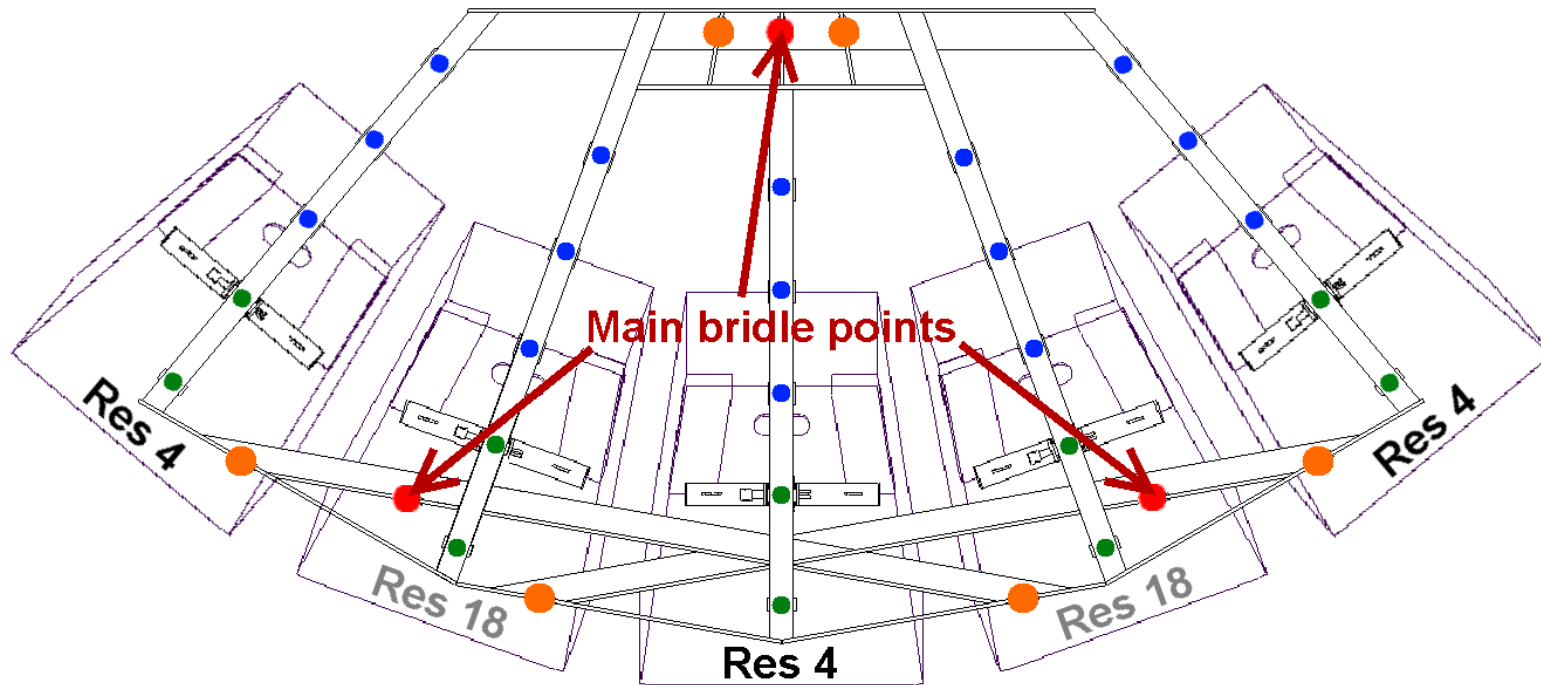


Fig 4.4-17 FG55 grid showing main bridle points for a 3 x Resolution 4 columns (plus optional 2 x Resolution 18 columns if required)
(Inner hanger positions for just 1 or 2 cabinets per column - or for more up-tilt)
Unused bridle points (indicated with orange dots) may be used for safeties

Typical FG55 house left grid layout – 2 x Resolution 4 (plus optional 2 x Resolution 18) on outer hanger points
 (Note the CW55 counterweight position to offset the weight of the unused grid spoke. The final CW55 position is best determined on site)

- Column hanger points
- Tilt straps fit behind these points

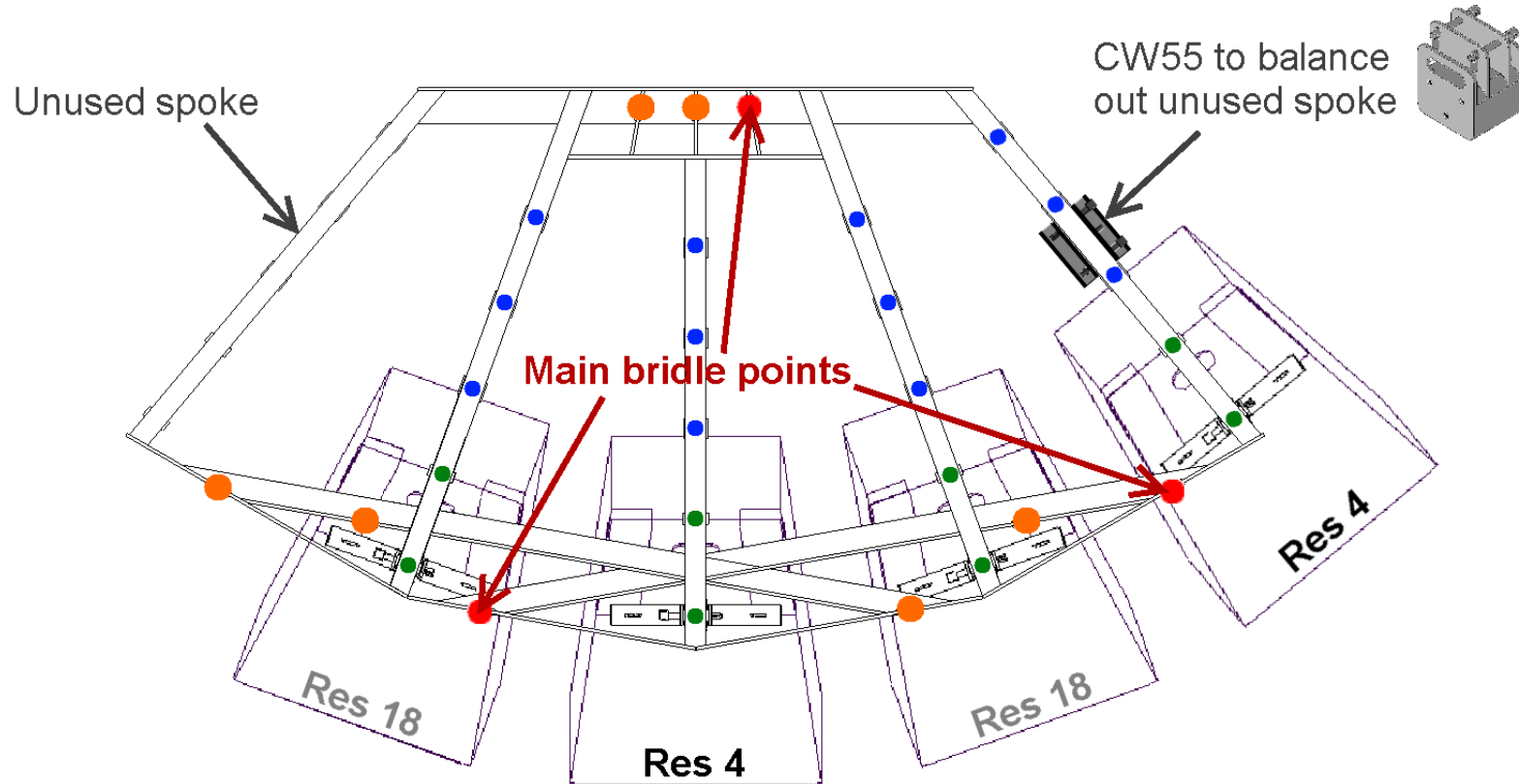


Fig 4.4-18 FG55 grid showing main bridle points for a 2 x Resolution 4 columns (plus optional 2 x Resolution 18 columns as shown)
 (Outer hanger positions for 3 cabinets per column - or for more down-tilt)
 Unused bridle points (indicated with orange dots) may be used for safeties

Typical FG55 house right grid layout – 2 x Resolution 4 (plus optional 2 x Resolution 18) on outer hanger points
 (Note the CW55 counterweight position to offset the weight of the unused grid spoke. The final CW55 position is best determined on site)

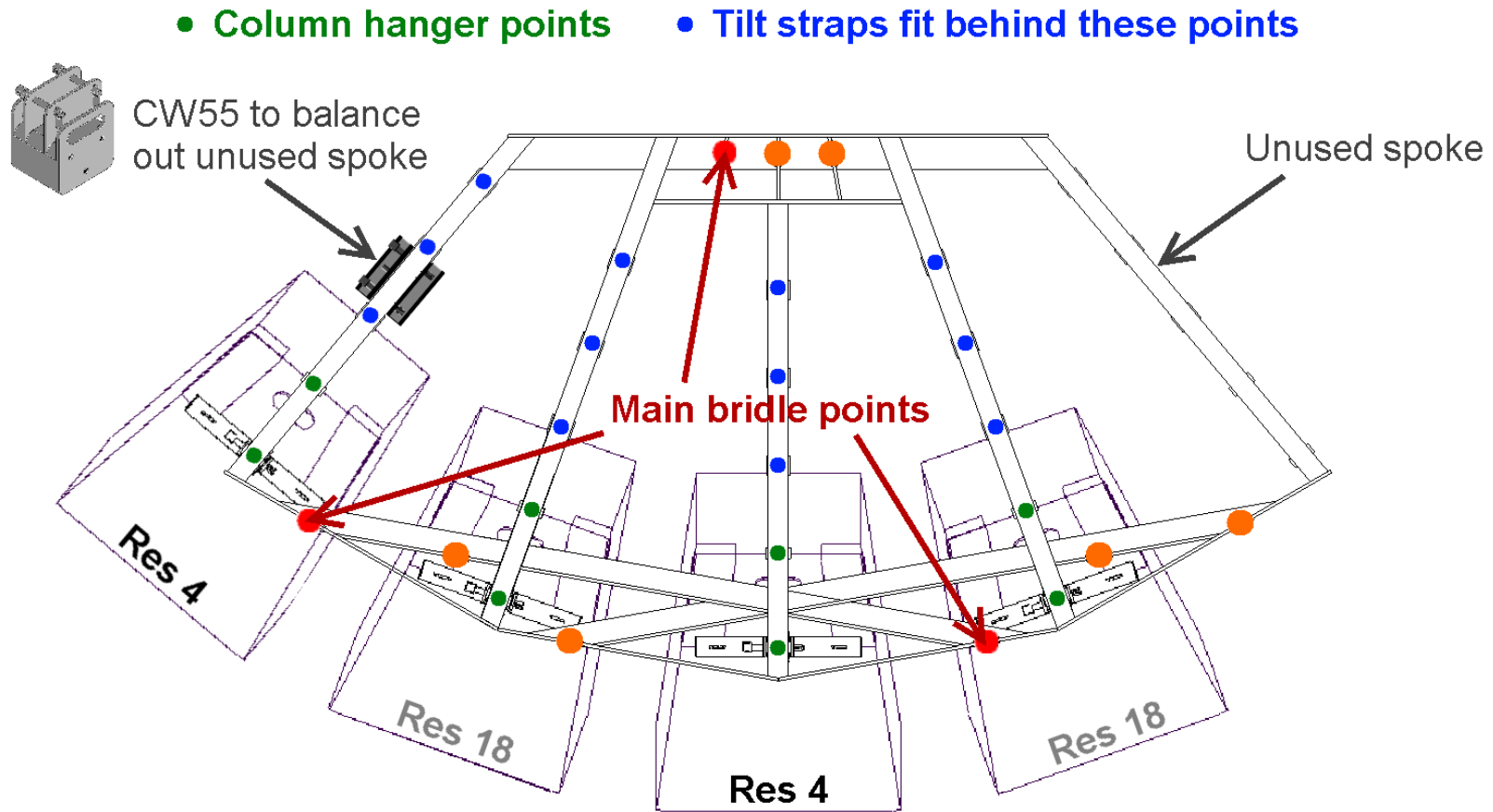


Fig 4.4-19 FG55 grid showing main bridle points for a 2 x Resolution 4 columns (plus optional 2 x Resolution 18 columns as shown)
 (Outer hanger positions for 3 cabinets per column - or for more down-tilt)
 Unused bridle points (indicated with orange dots) may be used for safeties

Typical FG55 house left grid layout – 2 x Resolution 4 (plus optional 2 x Resolution 18) on inner hanger points
(Note the CW55 counterweight position to offset the weight of the unused grid spoke. The final CW55 position is best determined on site)

- Column hanger points
- Tilt straps fit behind these points

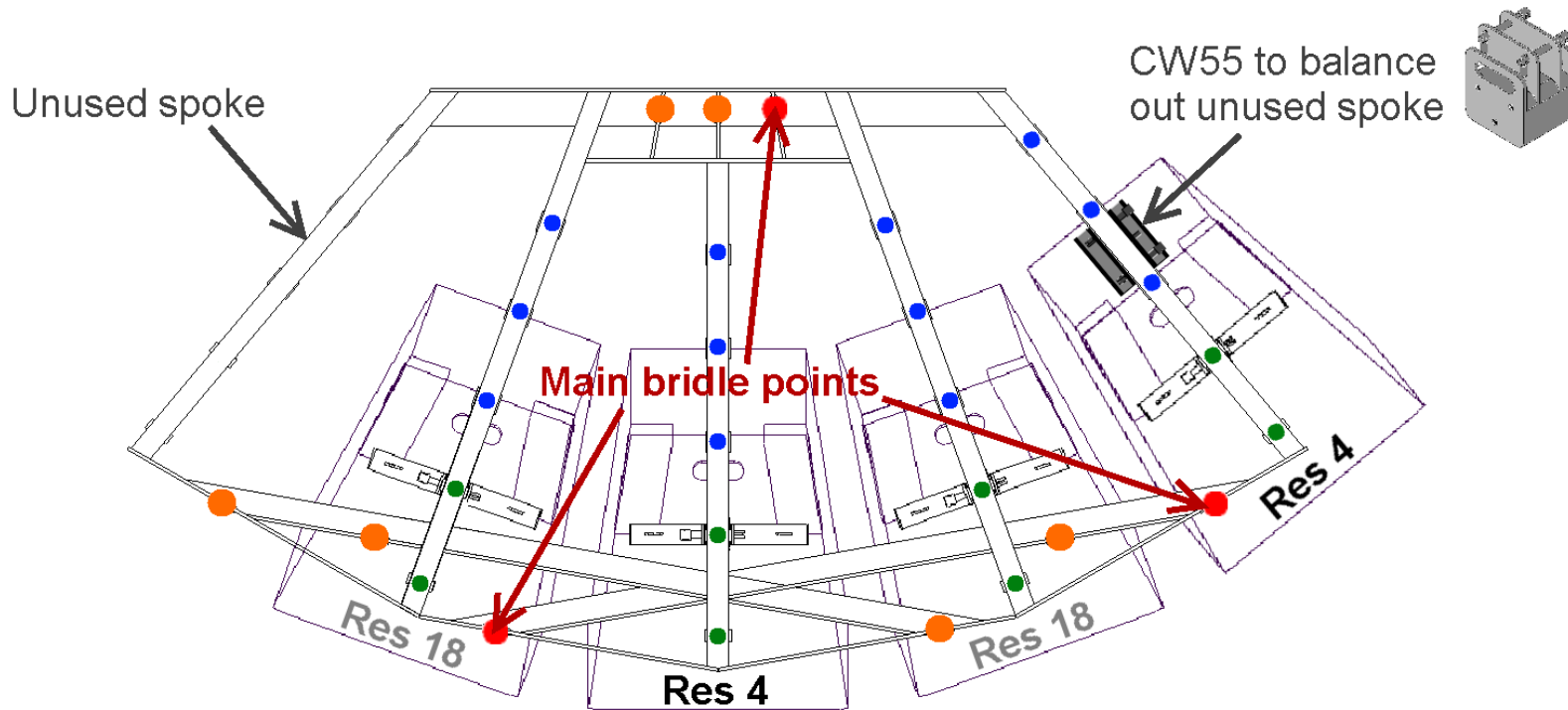


Fig 4.4-20 FG55 grid showing main bridle points for a 2 x Resolution 4 columns (plus optional 2 x Resolution 18 columns as shown)
(Inner hanger positions for just 1 or 2 cabinets per column - or for more up-tilt)
Unused bridle points (indicated with orange dots) may be used for safeties

Typical FG55 house right grid layout – 2 x Resolution 4 (plus optional 2 x Resolution 18) on inner hanger points
 (Note the CW55 counterweight position to offset the weight of the unused grid spoke. The final CW55 position is best determined on site)

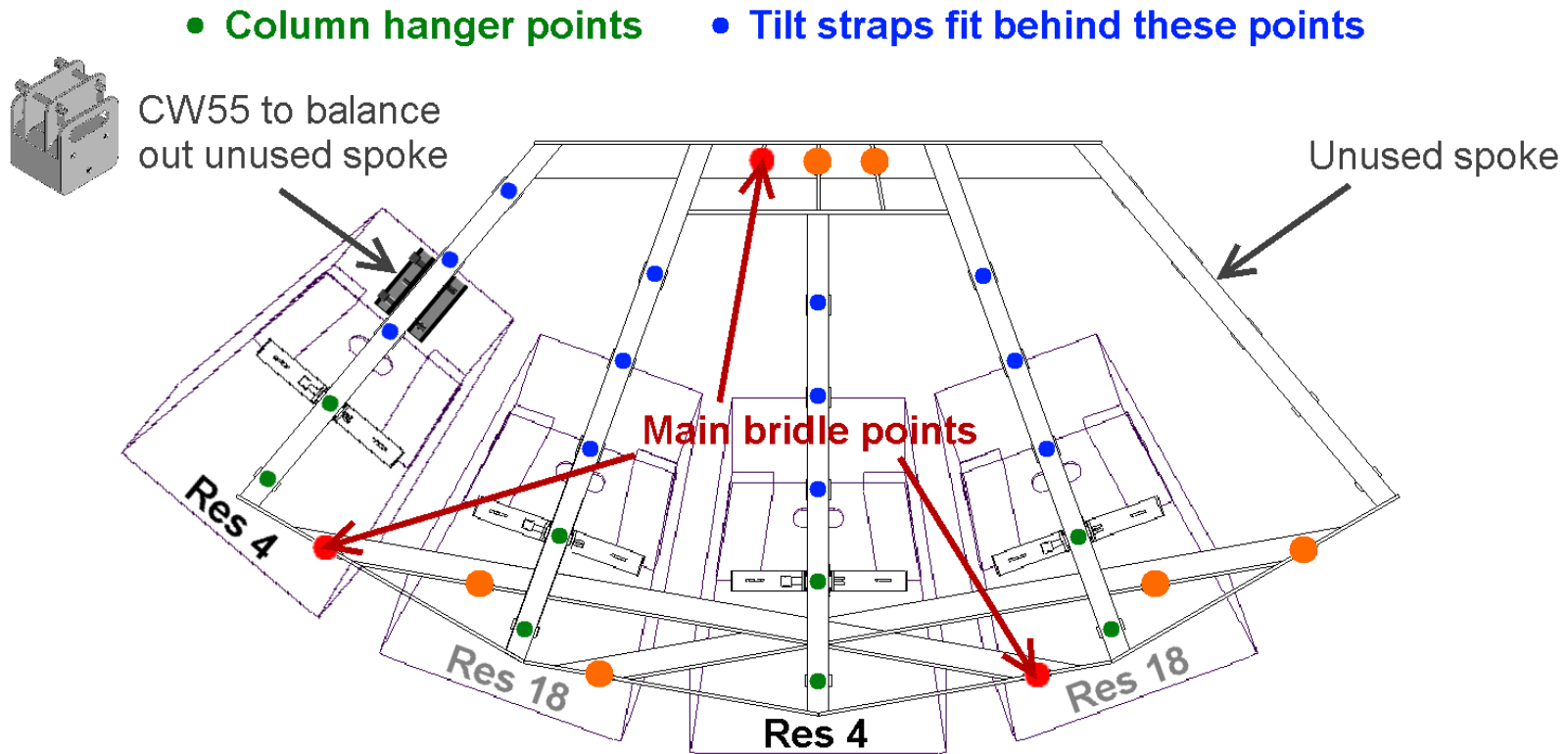


Fig 4.4-21 FG55 grid showing main bridle points for a 2 x Resolution 4 columns (plus optional 2 x Resolution 18 columns as shown)
 (Inner hanger positions for just 1 or 2 cabinets per column - or for more up-tilt)
 Unused bridle points (indicated with orange dots) may be used for safeties

4.5 Resolution 4/5 touring system rigging procedure

(5-wide Resolution 5 example shown)

Grid

The grid is lifted via a BR5 3-leg bridle and three Funktion One SG325 bow shackles. When the system is picked up by a motorised chain hoist (out of shot), the bridle height allows room for the chain bag.



Fig 4.5-1 Grid spokes give the optimum horizontal splay angle (20 degrees for Resolution 5, 40 degrees for Resolution 4)

Hand chain hoist

A hand operated 0.5T hand chain hoist (blue mechanism) forms the back leg of the bridle to enable simple grid levelling.

The hand chain hoist's drive chain should be tucked behind the guide bar provided.

Use the drive chain to ensure the grid is horizontal from the outset. This will make the array assembly easier.

Re-level as necessary during array assembly.

< **Fig 4.5-2** Rear view of the grid with hand chain hoist attached via an SH325 bow shackle

The 5-way grid can also be used to fly three and four wide clusters – i.e. 5 x Resolution 5, or 3 x Resolution 4 with Resolution 18 in between
If a four wide cluster is required then the three bridle legs are moved to additional shackle points on the grid to retain balance. A CW55 16.5kg counter-weight is available to offset the weight of the opposite unused spoke.

See plan views earlier...

The front bridle leg is attached to the appropriate grid point via a bow shackle – see grid layouts (Figs 4.4-8 to 4.4-21) earlier.

Hanger attachment points can be seen on the grid spokes.

For deep clusters (3-4 cabinets plus a downfill), hang the columns from the front point on the spoke to counteract a deep cluster's tendency to develop an upwards tilt.

For shallower clusters (1-2 cabinets plus a downfill), the top boxes can be brought closer together by using the point further back on the spoke.

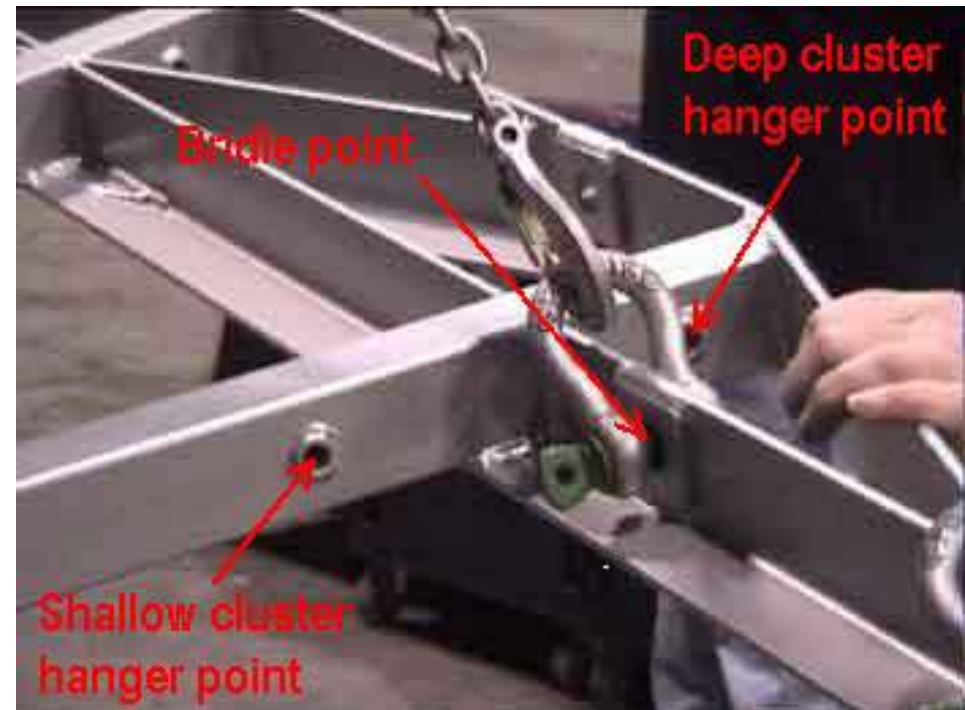


Fig 4.5-3 Bridle and hanger points

CH5 column hangers

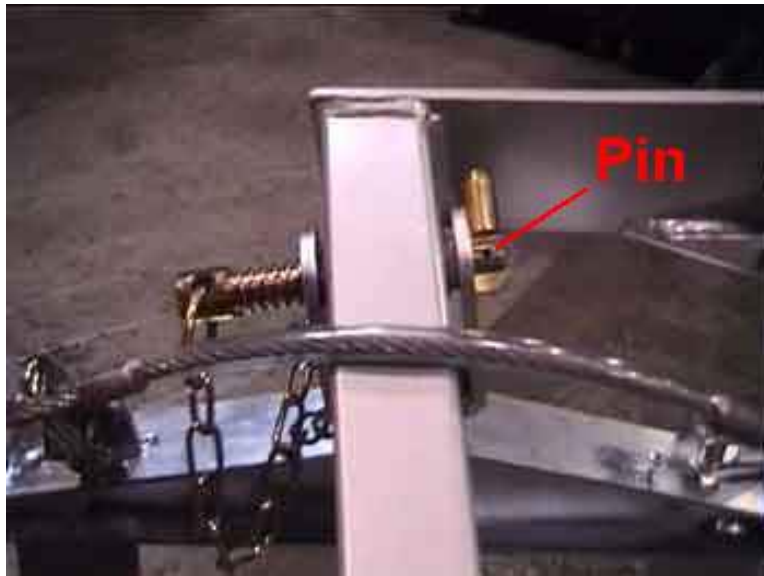


Fig 4.5-4 Column hanger attachment

Tip!

Keep the sword pin's drop-nose pivot point vertical to prevent the nose from dropping inside the grid box section.

Pass the safety steel over the grid and secure in to the other side of the column hanger place with a carbine (snap) hook.

CH5 column hangers are attached to the appropriate spoke of the grid by spring-loaded drop-nose sword pins that are captive to the column hanger.



Fig 4.5-5 Front view of a column hanger attached to the grid



Fig 4.5-6 Enclosures aligned near the grid



Fig 4.5-7 Antiluce toggle pins on the enclosures ready to go...

Forward planning always makes rigging operations run more smoothly - especially if local crew are unfamiliar with the system.

Move your Resolution cabinets close to their final positions and float the grid (plus column hangers) at just the right height to align the cabinet toggle pins with the column hangers.

Note

The dimensionally identical Res 4 and Res 18 enclosures can also be flown from this FG55 grid. Should the wider dispersion Resolution 4s be used they should only be located on every other column - interspersed with Res 18s. We make several variants of this grid with increased horizontal angle between spokes specifically designed for Resolution 4s on their own.

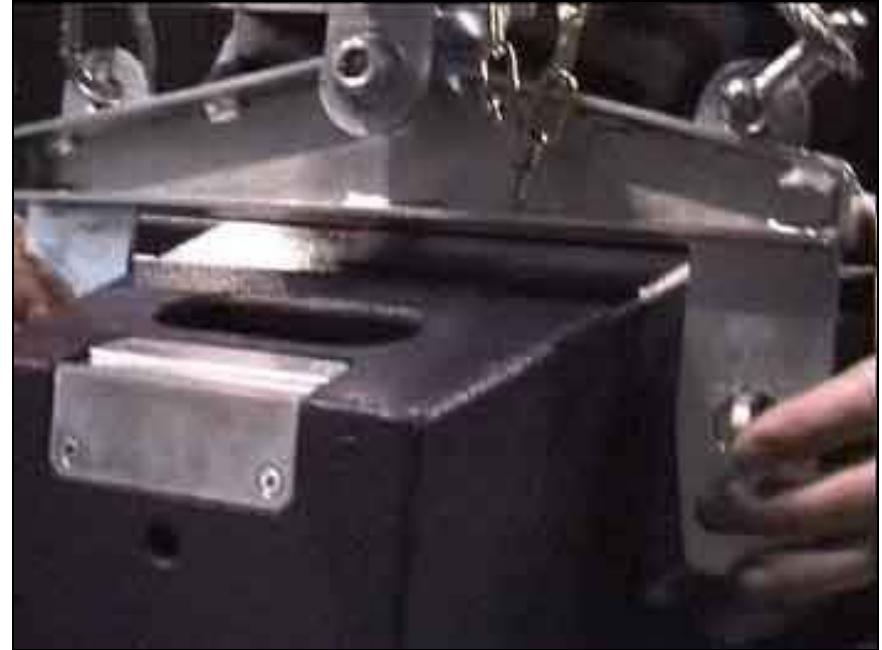


Fig 4.5-8 The integral antiluce toggle pins pass through holes in the CH5 column hangers.

See **Fig 4.5-9** overleaf...

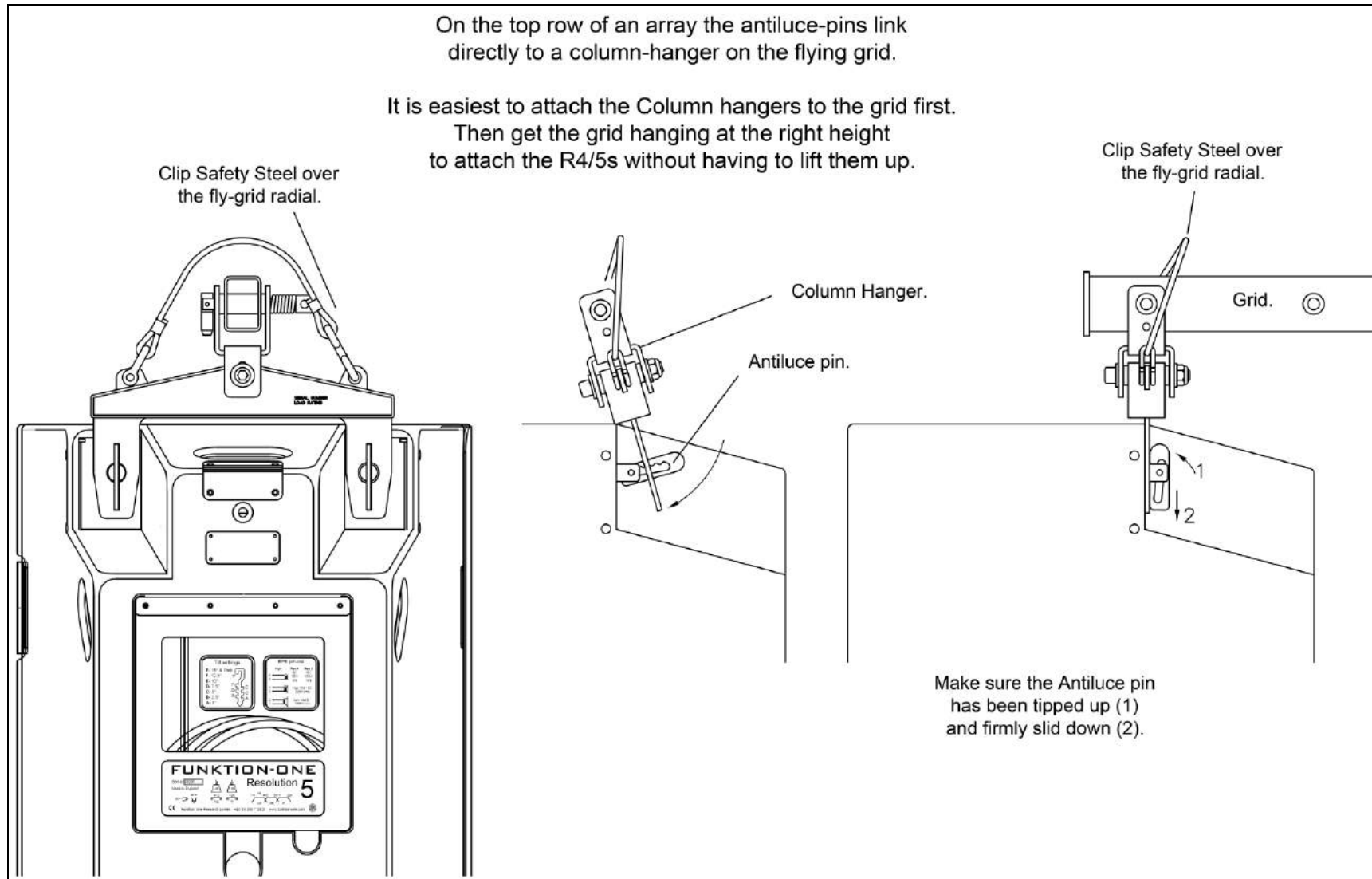


Fig 4.5-9 Hanger attachment and locking procedure

The toggle pins should then be latched in place to secure the cabinet.



Fig 4.5-10 The toggle pin mated with CH5 column hanger - and repeated with each enclosure on the top row.



Fig 4.5-11 Attach tilting straps to the grid using the smaller sword pin
(On a special fitting that forms part of the strap assembly)



Fig 4.5-12 Strap positions are marked with discs

These strap positions may be used for different vertical cabinet-to-cabinet splay angles – but should be left hanging freely from the grid at this point.

More on straps later...



Fig 4.5-13 Raise the grid & move the next row of enclosures in place



Fig 4.5-14 Wheelboards are removed by unfastening the flip catches

Note

- Five Resolution 5 per row are shown
- Three Resolution 4 plus two intermediate Resolution 18 per row will be the same width



Fig 4.5-15 Deploy the sprung flying tabs (from the cabinets above), place each one over the lower cabinet's toggle pins & securely latch each pin.



Fig 4.5-16 This is repeated for each enclosure in the second row

See **Fig 4.5-17** overleaf...

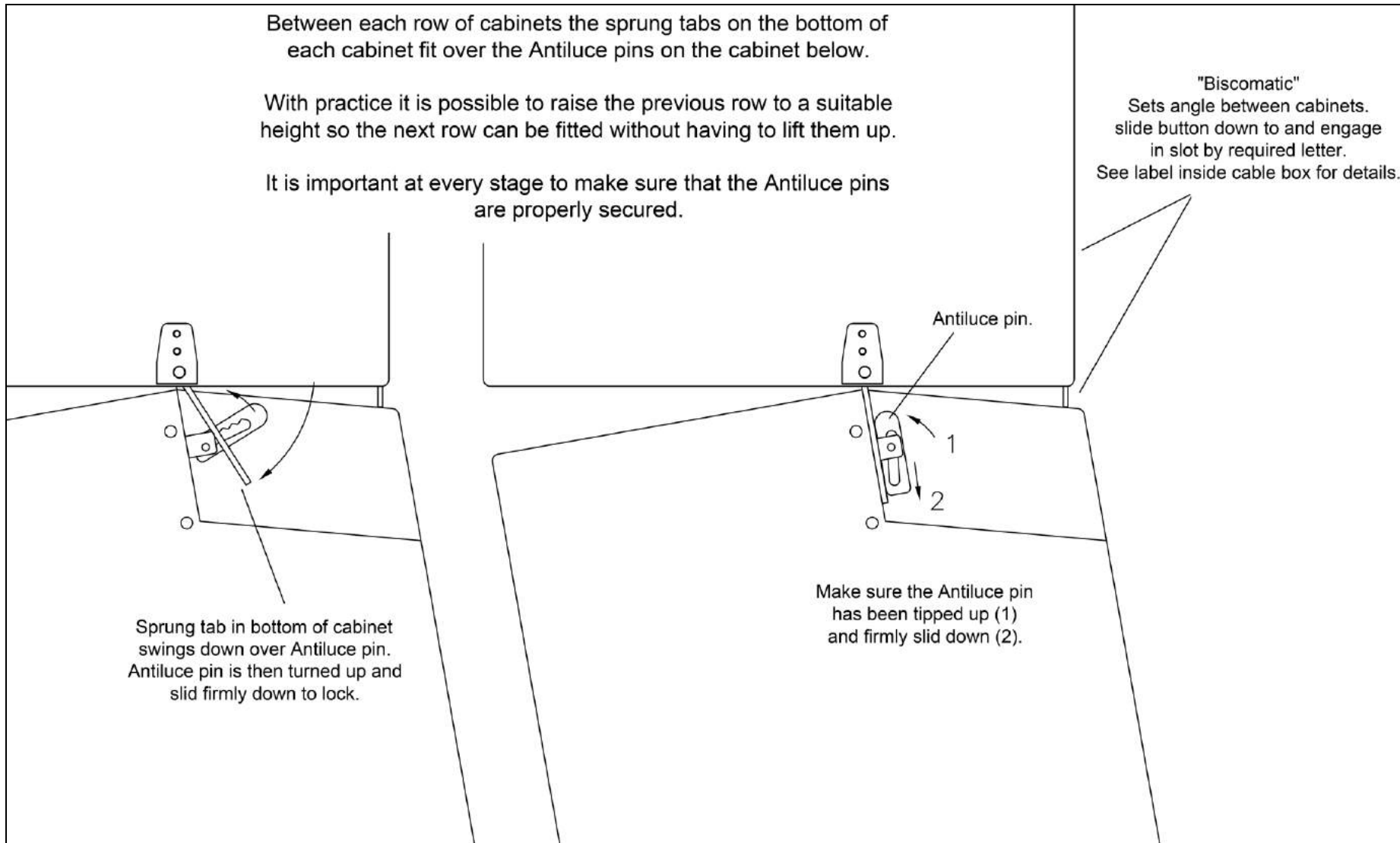


Fig 4.5-17 Enclosure-to-enclosure attachment and locking procedure

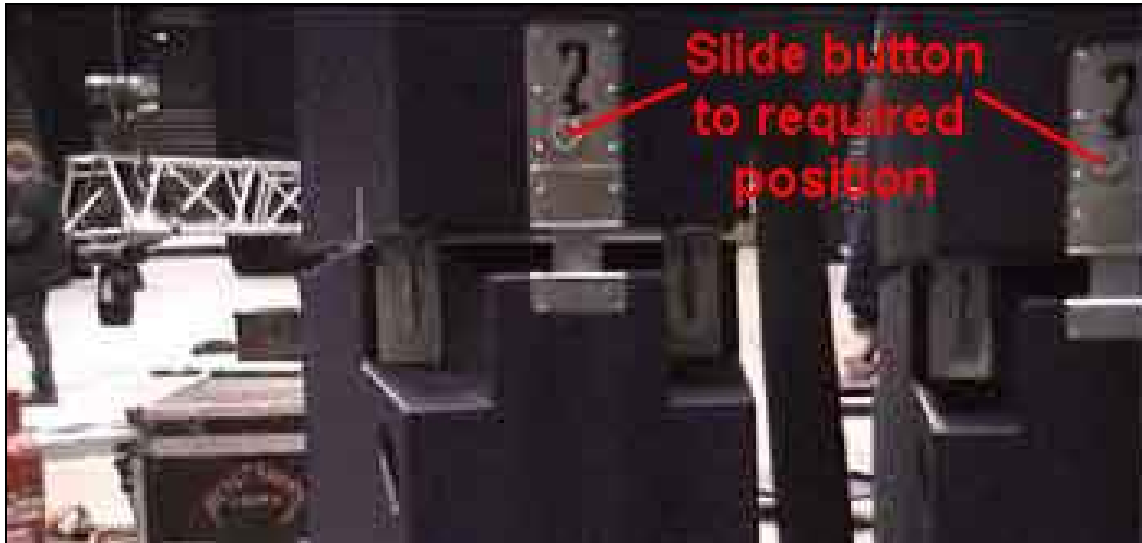


Fig 4.5-18 The 'Biscomatic' auto spacer must be set to achieve the required vertical splay angle between enclosures

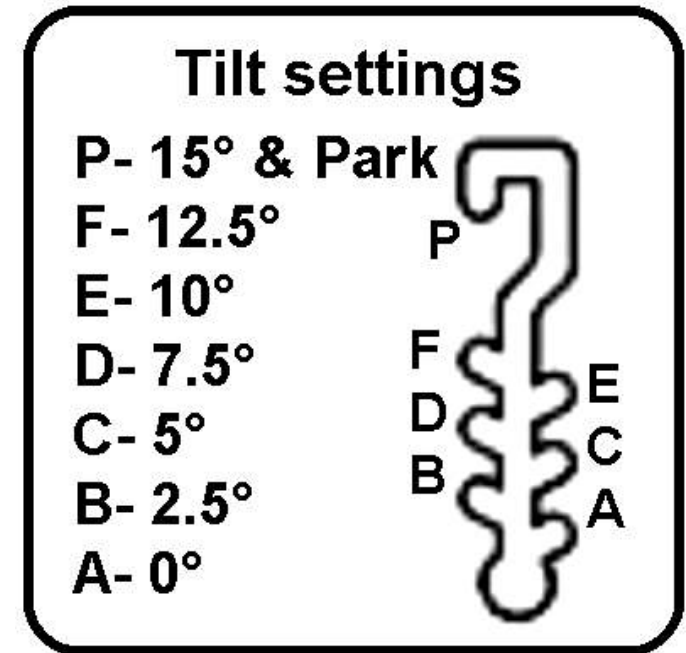


Fig 4.5-19 'Biscomatic' adjustment in 2.5° steps

These inter-cabinet angles can easily be adjusted later without having to ground the cluster.



Fig 4.5-20 The array can then be raised again ready for the next row of Resolution enclosures



Fig 4.5-21 The straps can be hooked into the bottom of the cluster and ratcheted to ensure a neat array with aligned bottom corners

Note again

Five Resolution 5 per row are shown.

Three Resolution 4 plus two intermediate Resolution 18 per row will be the same width.

See **Fig 4.5-23** for more tilt strap details...

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Adding Resolution 4D downfills

If downfills are required they can easily be added to the completed array.

Note that the Resolution 4D downfill cabinet has narrower horizontal coverage than the Resolution 4T but may be used beneath Resolution 4T/Resolution 18 combinations flown from FG53 or FG55 flying grids.



Fig 4.5-22 Again, sprung flying tabs are hinged out from the bottom of the cabinets above and mated with the downfills' toggle pins



Do not overload the flying system!

A maximum of **four** Resolution 4 or Resolution 5 cabinets - plus an additional downfill - may be flown via each column hanger from an FG series grid.

TS5 Tilt strap details

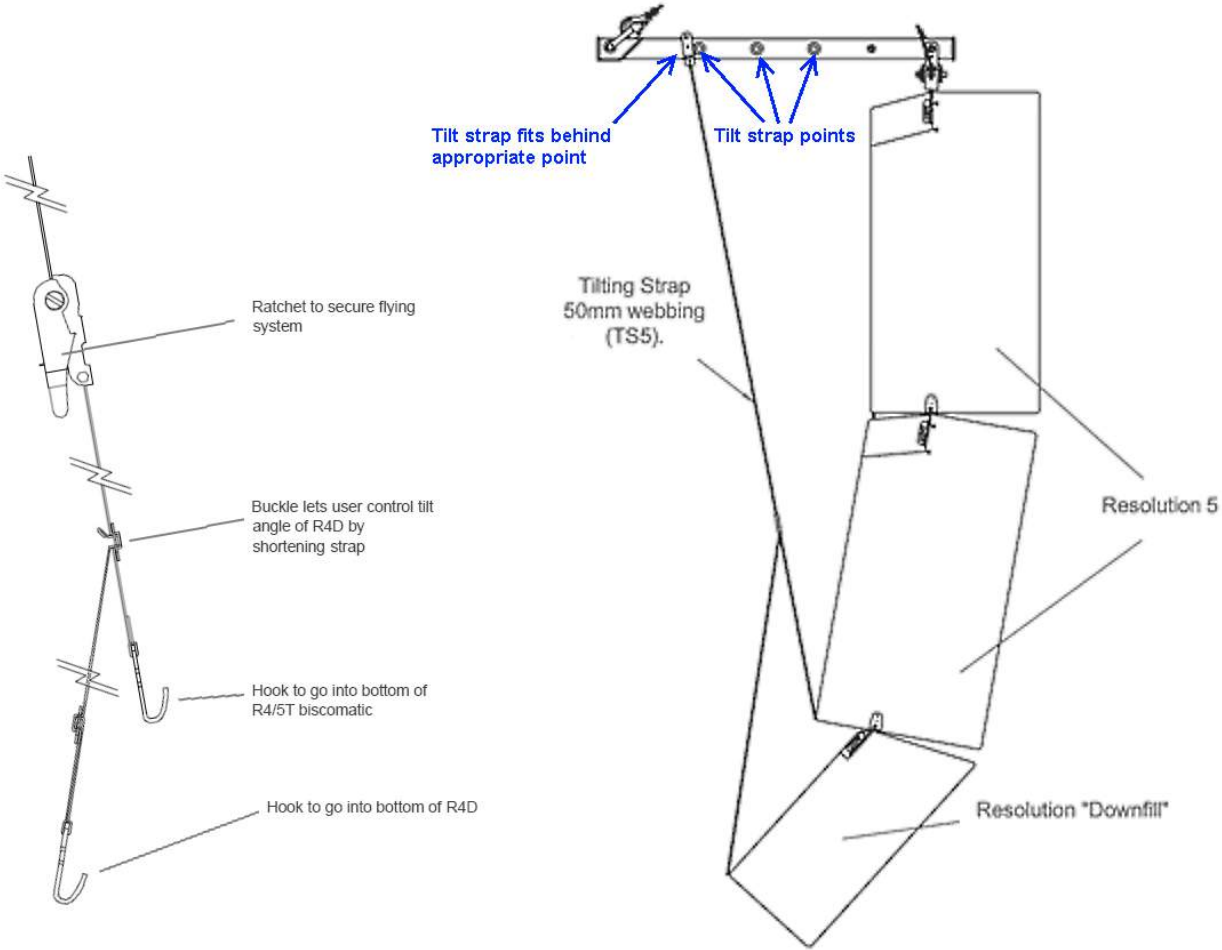


Fig 4.5-23 The TS5 lower strap hook is used to set the Resolution 4D downfill angle (Resolution 5 array shown).

Again, note that the Resolution 4D downfill cabinet has narrower horizontal coverage than the Resolution 4T but may be used beneath Resolution 4T/Resolution 18 combinations flown from FG53 or FG55 flying grids.

4.6 Stacking

Features:

- Ingenious design facilitates safe, secure and accurate R4/5 ground stacking
- Fast and Easy to set up
- Fixed and optimised horizontal array angles
- Vertical angle adjustment for controlled coverage
- The variety of available boards provide
- different stacking configurations for different environments
- Interchangeable parts can be used on different boards

Overview:

Funktion One's Ground Stack board system provides a safe, secure and accurate method for ground stacking Resolution 4 and 5, E and Touring enclosures on a variety of Funktion One bass. The System consists of a board which is clamped to the bass stack by mating brackets and secured by a strap that runs from the lowest bass handle on one side, up and over the board and down to the lowest handle on the other side.

With the board attached to the bass (and the bass stack secure), various metal brackets are slotted into the board which provide quick to use attachment points for the Resolution enclosures. The boards themselves have no permanent attachments making them easy to transport without snagging.

Resolution 4 boards provide the optimal 40° horizontal array angles between enclosures. Several different boards are available which provide for all of the most commonly used stacking configurations. The metal mating parts and straps are common to all boards and can therefore be inter-changed.

Ground Stack Boards are usually supplied as complete kits but can be purchased on their own for users that want the flexibility of multiple stack configurations with a common set of mating parts. Touring Resolution 4 enclosures can be safely stacked two high on top of the bass cabinets (assuming solid and flat ground) using the board system combined with the integral flying linking hardware provided on the enclosures themselves.

Resolution 4E enclosures can be stacked one row high. All parts are common with the exception of the rear anchor and strap which are either dedicated to the touring or E enclosures.

Stacking at a glance

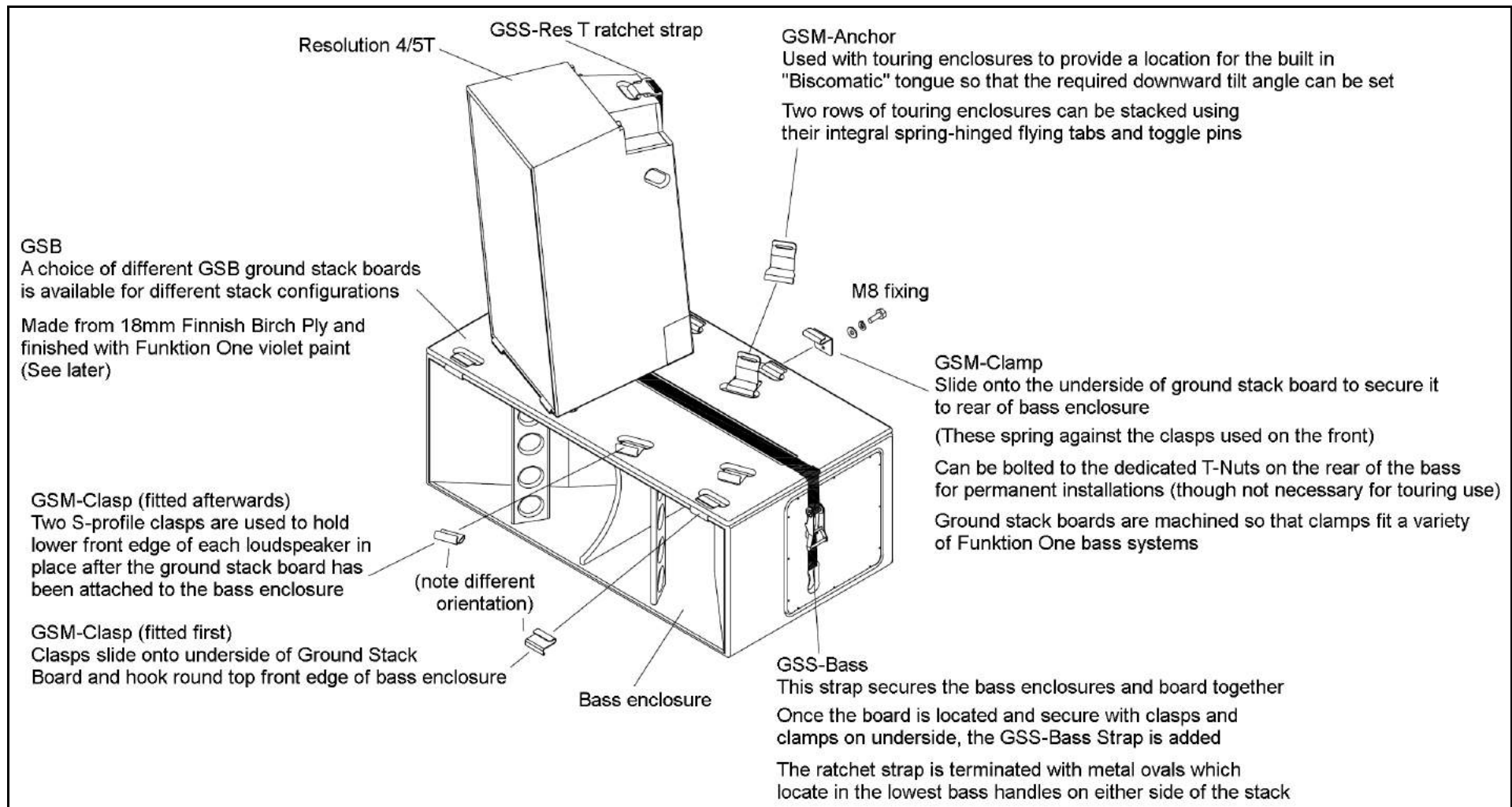


Fig 4.6-1 Resolution 4/5T illustrated - Res 4 series and Res 5 series use similar techniques and many common parts

Resolution 4/5T stacking - rear view

(The Resolution 4T & 5T details are the same)

Overview

- Straight, ratchet-adjustable GSS-ResT tilt strap system available
- Choice of GSB ground stack boards
- GSM-Anchor and GSM-Clamp available
- GSS-Bass ratchet strap available

The ResT strap (**GSS-ResT**) has a hook at each end and runs from the handle in the top of the touring enclosure to the slot present in either type of anchor. This strap is long enough for three vertically linked touring enclosures, although in normal use we advise a maximum of two rows.

Note

The Resolution 4/4T cabinets may also be used with:

- The GSM-Anchor E tilt system which provides greater declination than the touring anchor
- The GSS-Res E strap system

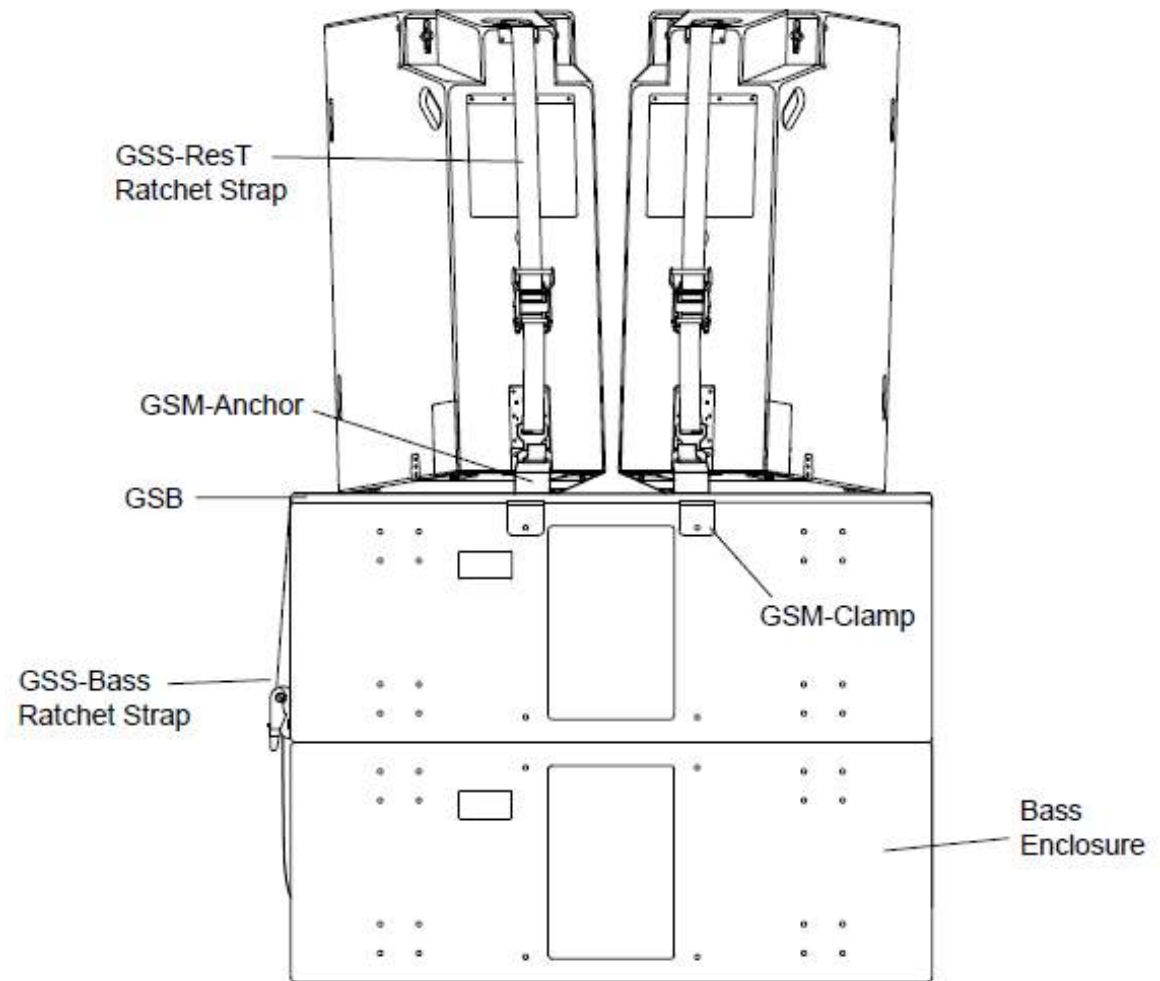


Fig 4.6-2 Rear view of Resolution 4/5T stack

Resolution 4/5E stacking - rear view

(The Resolution 4E & 5E details are the same)

GSM-Anchor E

Originally designed for use with the Resolution E enclosures, which do not have the built in "Biscomatic", the E-Anchor facilitates external downward tilt angle adjustment for both Res 4/4E and Res 4/4T cabinets

The rear of the enclosure rests on a captive block which can easily be moved to different heights for different downward angles.

GSS-ResE

This Y-strap is required for each anchor position.

The lower end of the ResE Y-strap (**GSS-ResE**) is threaded to the E-Anchor and once threaded can be left attached. The upper ends are secured by metal ovals that locate in the side handles.

The indexed block in the E-Anchor sets the declination of the enclosure. The strap is tightened just sufficiently to secure the R4/5 E.

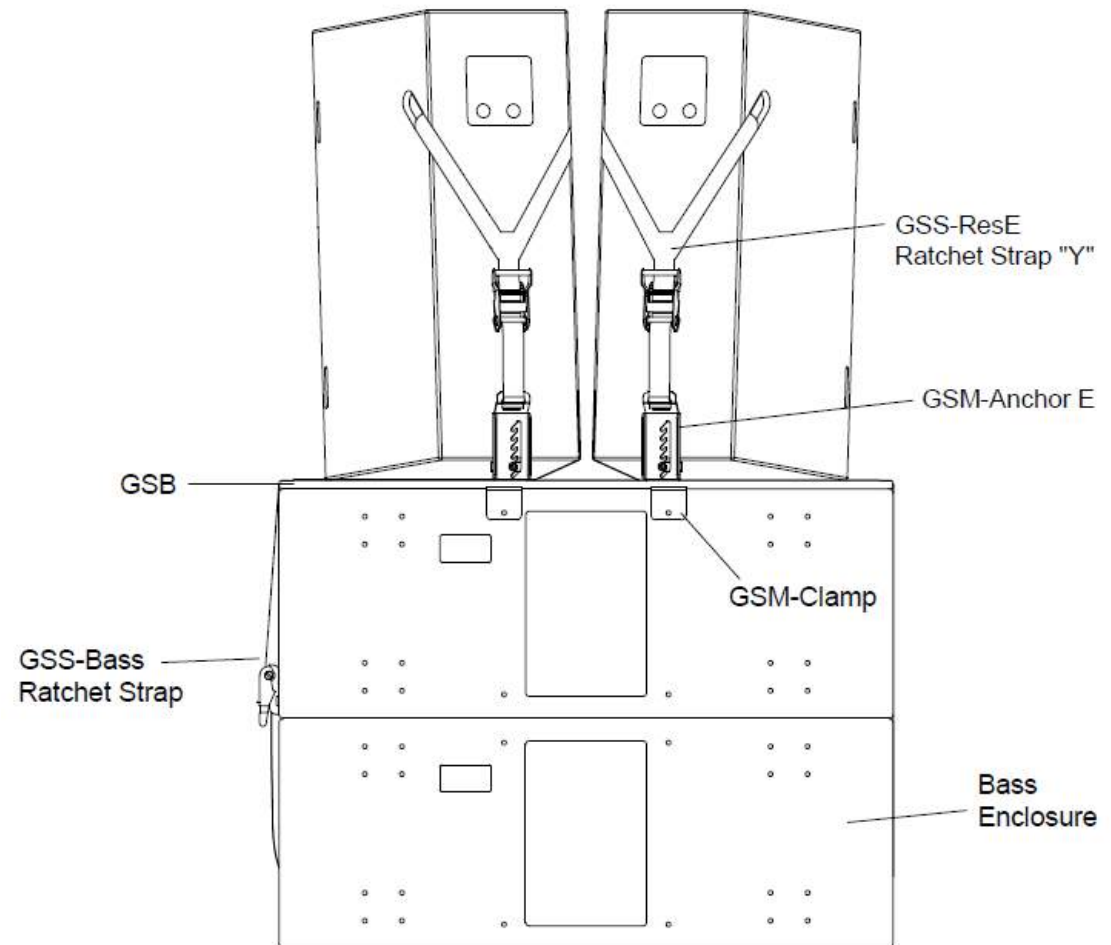


Fig 4.6-3 Rear view of Resolution 4/5E stack

Please note

Only one row of E enclosures can be deployed in this way

Resolution 4/5 series rear anchor options

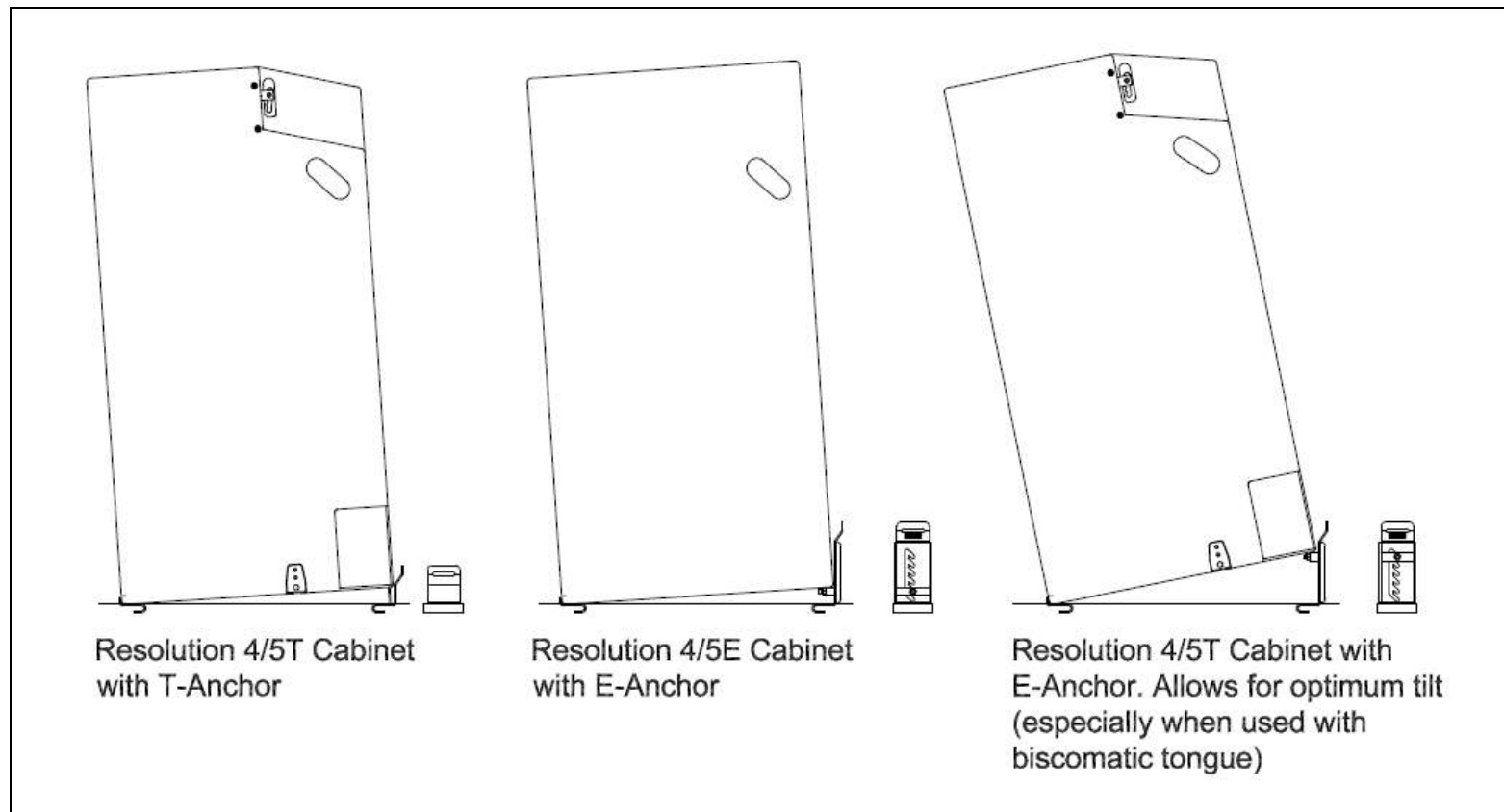


Fig 4.6-4 Resolution 4/5 series rear anchor options

The illustration shows - from left to right:

- Resolution 4/4T cabinet with T-anchor - uses the rear 'Biscomatic' for tilt adjustment
- Resolution 4/4E cabinet with E-anchor - has moveable block for a wide range of tilt adjustment
(Limited to one row of Resolution 4/4E only)
- Resolution 4/4T cabinet with E-anchor - used in conjunction with rear 'Biscomatic' for a wider range of tilt adjustment

Resolution 4T & 4E ground stacking board options

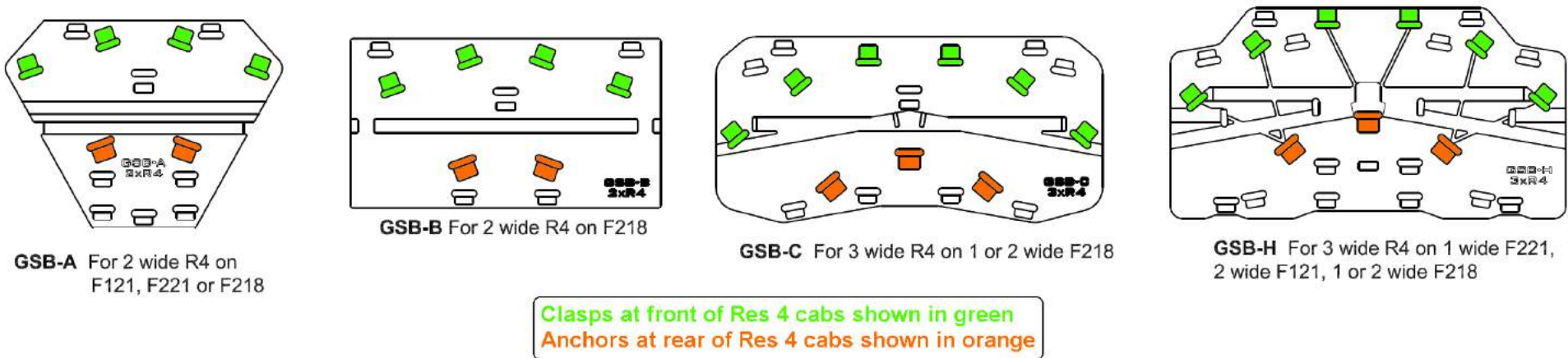


Fig 4.6-5 Loudspeaker-to-board clasps (front - in green) and anchors (rear- in orange)

See next page for a 2-way example showing how a GSB-A ground stack board is attached to various bass cabinet combinations...

GSB-A 2-wide ground stack board deployment with F221, F221 and F218

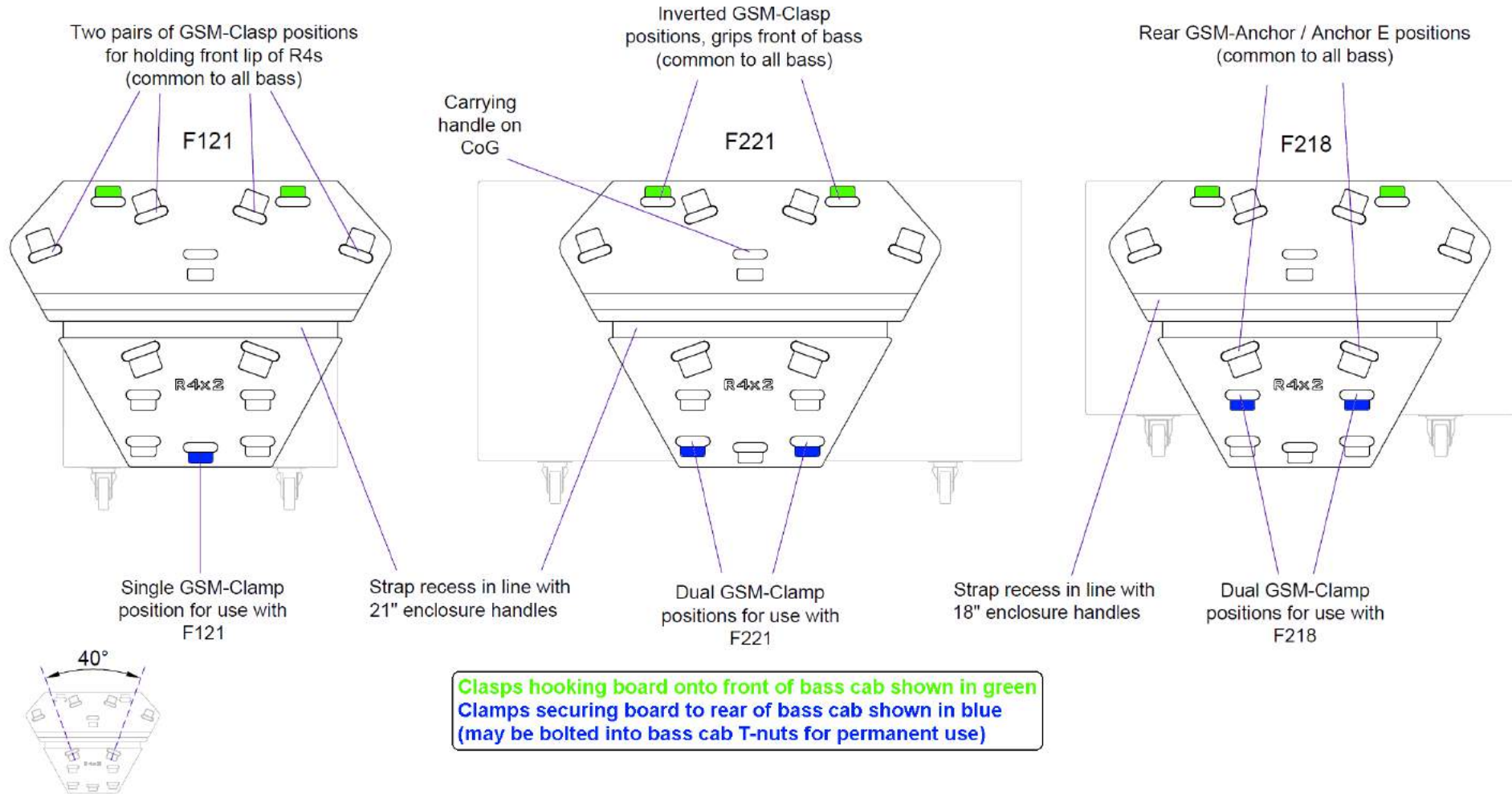


Fig 4.6-6 Ground stacking board-to-bass cabinet clasps (front – in green) and clamps (rear – in blue)

5 System design

5.1 Hearing safety



Enjoy your system responsibly

Funktion One loudspeaker systems are designed to provide extensive audience coverage at low distortion and are capable of producing very high near-field sound pressure levels.

The richness and impact of a powerful sound system can be great fun and very exhilarating; but please enjoy your Funktion One system responsibly by following the advice below...

- Design your system for good projection and coverage without overexposing specific audience areas to damaging levels. Individual audience members should not be exposed to levels significantly greater than levels at the mix position.
- Don't place your ears too close to high power loudspeaker systems during system set-ups. Erroneous patching or un-muting by others could generate unexpected and damaging sound pressure levels during set-up.
- Wearing ear plugs may be a sensible precaution during system set-ups but remember that you have a duty of care towards the venue staff and the audience. Mix engineers, DJs, subcontractors and venue management should not make system level and equalisation decisions whilst wearing ear plugs as this could overexpose venue staff or the public in the vicinity
- Hearing loss is cumulative and can result from long-term exposure to sound pressure levels as low as 85dBA. Installers and get-in crew should consider long-term staff exposure when making high power loudspeaker placement and aiming decisions and managers should rotate staff - especially security staff at the front of the audience - to minimise the exposure of any one group.
- Check the relevant noise exposure/noise at work regulations and comply with them. If in doubt, seek expert advice.

If no noise exposure/noise at work regulation is available, we suggest the following LAeq* (A-weighted Equivalent Continuous spl) and peak spl limits for staff:

**LAeq is referred to as dBA Leq on some meters*

85dB LAeq - 8hrs

88dB LAeq - 4hrs

91dB LAeq - 2hrs

94dB LAeq - 1hr

97dB LAeq - 30mins

100dB LAeq - 15mins

Instantaneous/peak sound pressure levels must never exceed 137dB(C-weighted)

Leq is the average spl over a defined time period. We would suggest averaging and logging LAeq, and logging peak spl, over consecutive 10 minute periods. LAeq may be logged with an integrating spl meter or by using a calibrated microphone and IO with the appropriate sound measurement software.

Note!

We're not being party poopers here! Unweighted instantaneous sound pressure levels (especially where there's a solid bass presence) will be considerably higher than the dBA LEQ figure which has significantly reduced LF and HF sensitivity and is averaged over a considerable time period.

5.2 Calculating array coverage

Apart from its superior impact, clarity and detail, one major advantage of a Funktion One array is the ability to tailor the system's vertical **and** horizontal coverage to suit the venue or audience shape.

The rules of thumb governing horizontal and vertical coverage are pretty simple. You can do the sums in your head.

Furthermore, with a bit of patch planning, you don't have to be stuck with fixed full-venue coverage when the venue is empty during a sound check. Once you've aligned your coverage in all areas, it may be possible to reduce coverage to, for instance, the arena side seating for some periods of the sound check, to enable the sound operator to concentrate on his mix without having to listen through empty room acoustics.

5.2.1 Horizontal coverage

Horizontal coverage is easy to calculate where Resolution 4 systems are flown from FG42, FG42, FG53 or FG55 grids with fixed horizontal splay angles.

The calculation for Resolution 4 array coverage is . . . 50° (Res 4 coverage) + the sum of the inter-cabinet angles provided by the flying grid.

Horizontal coverage examples:

1 x Res 4 = 50°

2 x Res 4 on FG42 is 50° (Res 4 coverage) + 45° (FG42 inter-cab angle) = 95°

2 x Res 4 on FG43, FG53 or FG55 is 50° (Res 4 coverage) + 40° (inter-cab angle) = 90°

3 x Res 4 on FG43 or FG55 is 50° (Res 4 coverage) + $2 \times 40^\circ$ (inter-cab angles) = 130°

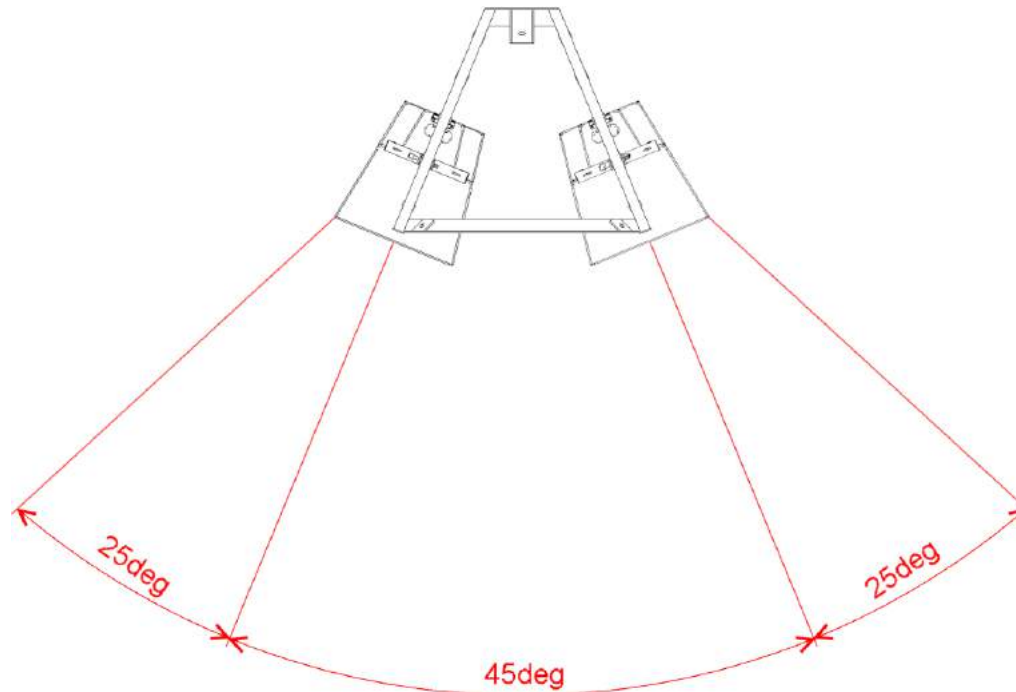


Fig 5.2.1-1 2-wide 95° example on FG42 grid (Bridles & safeties not shown)
Note that the FG42 has a 45° inter-cabinet angle to cater for typical 2-wide high-tilt applications.

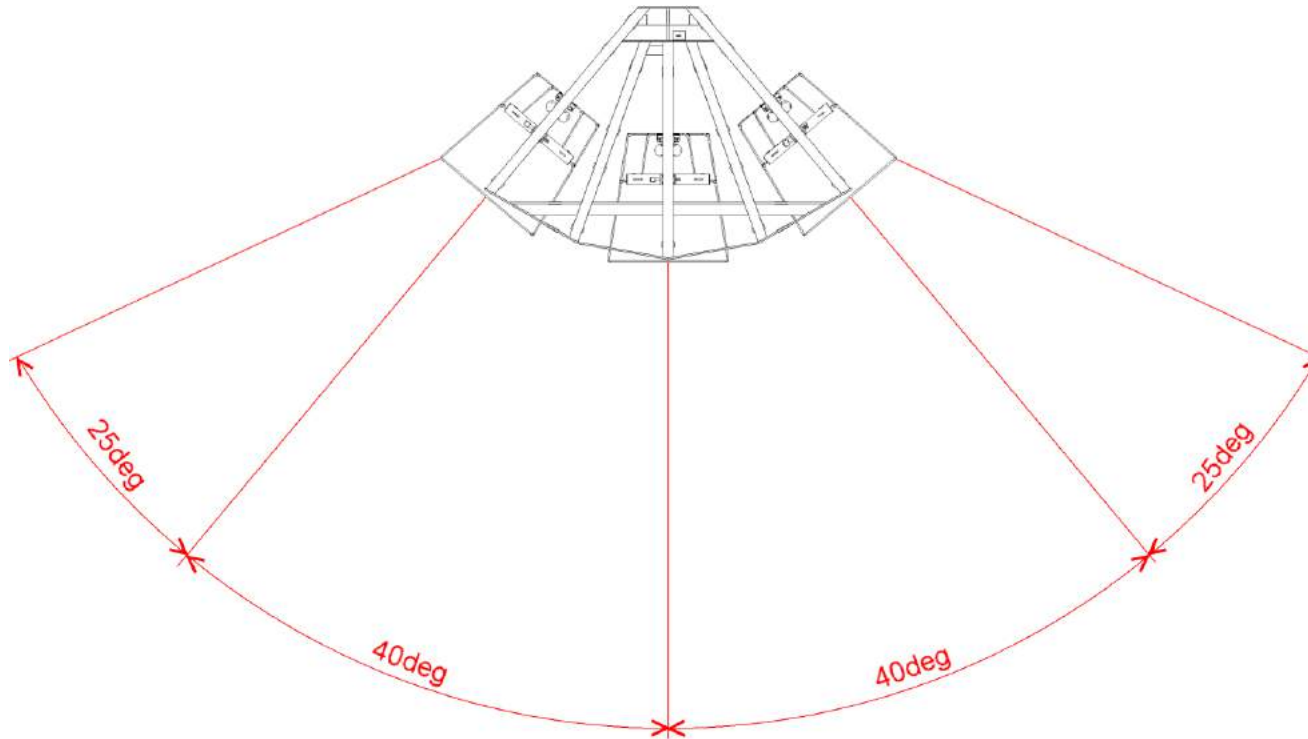


Fig 5.2.1-2 3-wide 130° example on FG43 grid (Bridles & safeties not shown)



Do not overload the flying system!

A maximum of **four** Resolution 4 cabinets - plus an additional downfill - may be flown from each column hanger

5.2.2 Vertical coverage

Vertical coverage is calculated in a similar way to the horizontal coverage but with two differences:

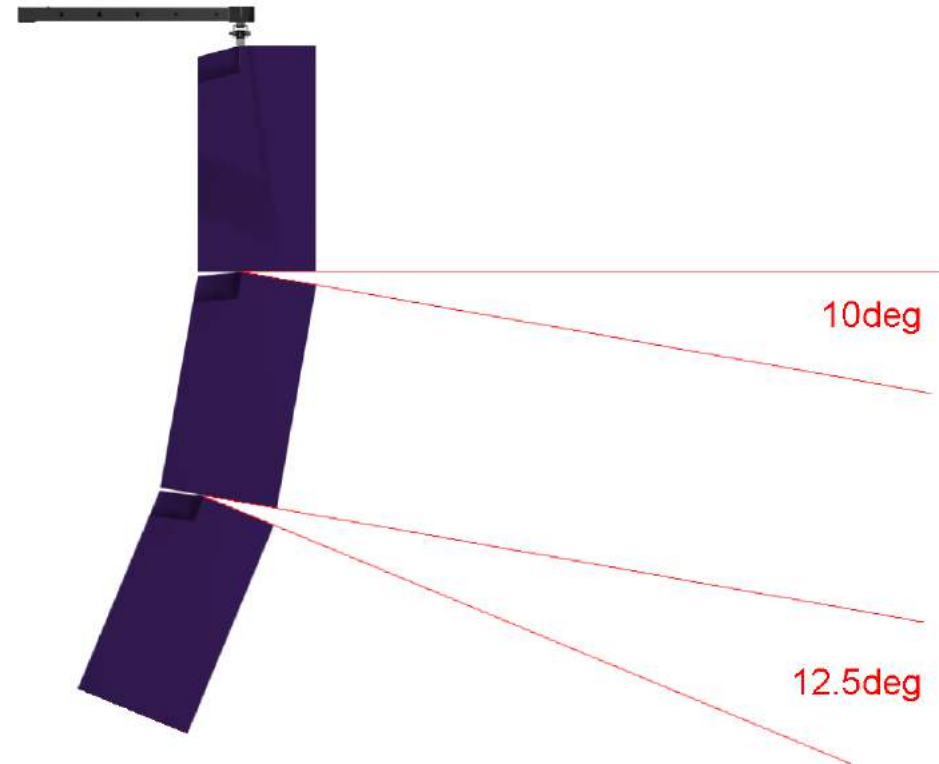
- 1) You will need to take the user selectable inter-cabinet "Biscomatic" settings into account
- 2) The calculation will vary depending on whether you're using Resolution 4D Downfills or not

For Resolution 4T arrays without downfills the sum is:

25° (Res 5 vertical coverage) + the sum of all the inter-cabinet angles.

For the example shown here, the vertical coverage is:

$$25^\circ + (12.5^\circ + 15^\circ) = 52.5^\circ$$



**Fig 5.2.2-1 3-deep, 47.5° example
(Bridles, safeties & tilting straps not shown)**

Resolution 4T/Resolution 18 combinations (from FG53 or FG55 grids) with downfills

When calculating the full vertical coverage, including the downfill, we need to take the following into account:

- 1) The Resolution 4D's compatible dimensions and fittings allow it to be hung directly beneath the bottom Resolution 4 and set to a range of angles by adjusting the lower TS5 tilting strap hook for the front row coverage required
- 2) The Resolution 4D's 25° sloping top has been designed to coincide with the upper half of its 50° vertical coverage and sets a maximum main-to-downfill overlap of 12.5° when tight-packed beneath the bottom Resolution 4. (We call this 0° in our calculations)
- 3) The recommended crossover time alignment setting (see *Section 7.5*) ensures a seamless transition between the Resolution 4 and the Resolution 4D
- 4) A few degrees of extra tilt may be applied to the Resolution 4D to increase vertical coverage

For Resolution 4 arrays with downfills, the sum is:

62.5° + the sum of all the inter-cabinet angles*

(*This must include any extra splay angle between the downfill's sloping top and the bottom of the lowest Resolution 4).

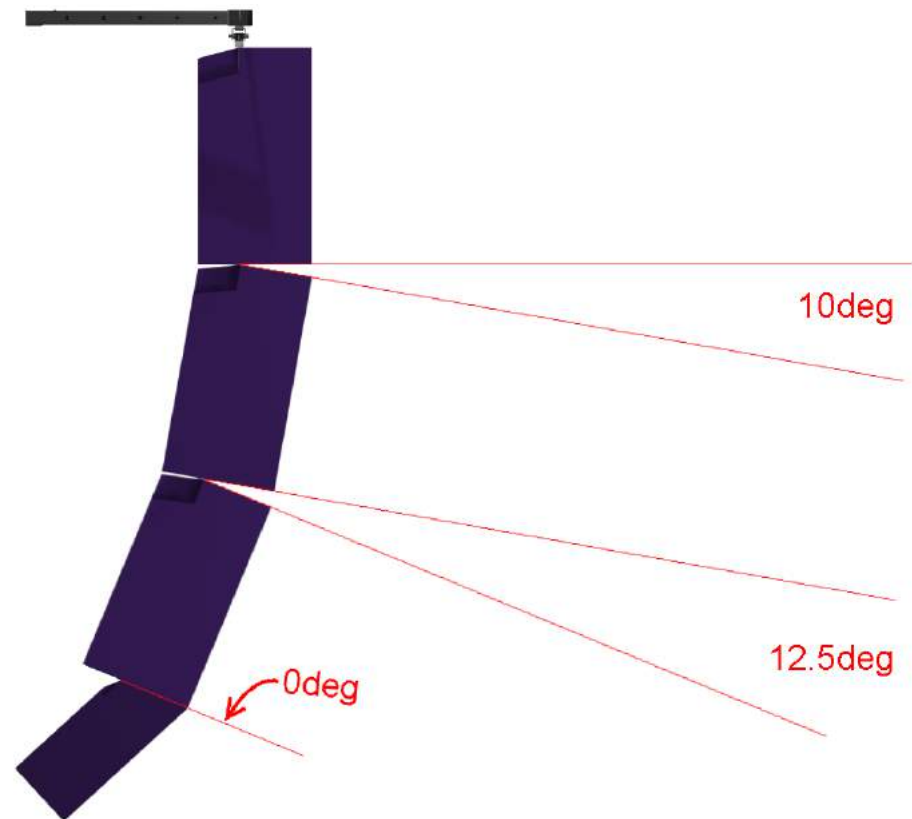
For the tight-packed downfill example shown here, the vertical coverage is:

62.5° + (10° + 12.5° + 0°*) = 85°

(*0° = tight-packed)

Q. Why 62.5°? Why not 25° (Res 4) + 50° (Res 4D) = 75°?

A. Because of the 12.5° degree overlap when the downfill is at 0° (i.e. tight-packed to the lower Res 4).



**Fig 5.2.2-2 3-deep + tight-packed downfill, 85° example
(Bridles, safeties & tilting straps not shown)**

Resolution 4T/Resolution 18 combinations (from FG53 or FG55 grids) with tilted downfills

Remember, for Resolution 4 arrays with downfills, the sum is:

62.5° + the sum of all the inter-cabinet angles*

*(*And this includes any splay angle between the downfill's sloping top and the bottom of the lowest Resolution 4).*

For the example shown here, with a 5° splay angle between the downfill's sloping top and the bottom of the lowest Resolution 4, the vertical coverage is:

$$62.5^\circ + (10^\circ + 12.5^\circ + 5^\circ) = 90^\circ$$

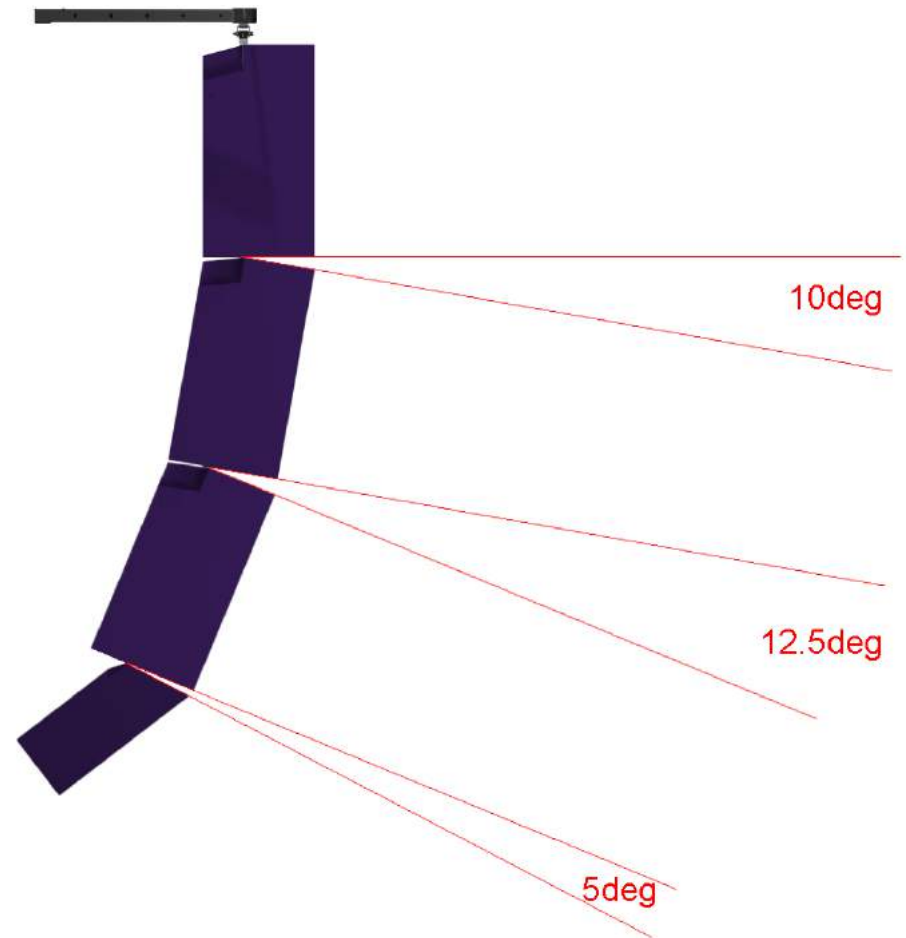


Fig 5.2.2-3 3-deep + tilted downfill, 90° example
(Bridles, safeties & tilting straps not shown)

5.2.3 Vertical coverage to suit venue profiles

Whether you're designing a large flown system for an arena or stadium or a smaller ground stacked system for a small festival stage or club, it's worth spending a few minutes looking at the venue's sectional profile and working out column heights and angles in order to optimise audience coverage and minimise slap-back.

Note that the following illustrations do not show full flying, stacking or bass clamping details. Refer to [Section 4](#) for flying and stacking information.

Optimising vertical coverage

Ground stacks - one high

Resolution 4E cabinets may be stacked (one-high) for small-medium clubs or music venues (clashed and strapped on a double height bass system, for instance).

Remember that mid and high frequencies are easily blocked off by audience members. Cabinets should be mounted on stage wings or small risers, just above audience head height, to ensure clear, unimpeded sound coverage to the furthest audience areas. Tilt the Res 4's so that they aim between 2/3rd and the full audience distance.



Fig 5.2.3-1 1-high Resolution 4E in a small-medium club or music venue. Aimed between 2/3rds & full audience distance using E-Anchor.

Note: Straps (not shown) must be used

Aiming just short of the furthest audience distance will provide smooth coverage whilst reducing slap-back from far walls. Systems may be aimed all the way back, however, if the rear of the venue is acoustically absorbent or fitted with diffusers - or if the venue is outdoors, of course.

Resolution 4E cabinets must never be stacked more than one high as there are no vertical link facilities. Use Resolution 4T units if 2-high stacks are required.

Ground stacks - two high

Two-high Resolution 4T arrays can be ground stacked for large indoor clubs or music venues (again, clasped and strapped on a double height bass system, for instance).

These are best mounted on a stage wing or riser to enable the bottom row to be placed just above audience head height and aimed approximately 1/3-1/2 way into the audience whilst the top row is aimed between 2/3rds the full distance and the furthest audience area - depending on the acoustical characteristics of the room.

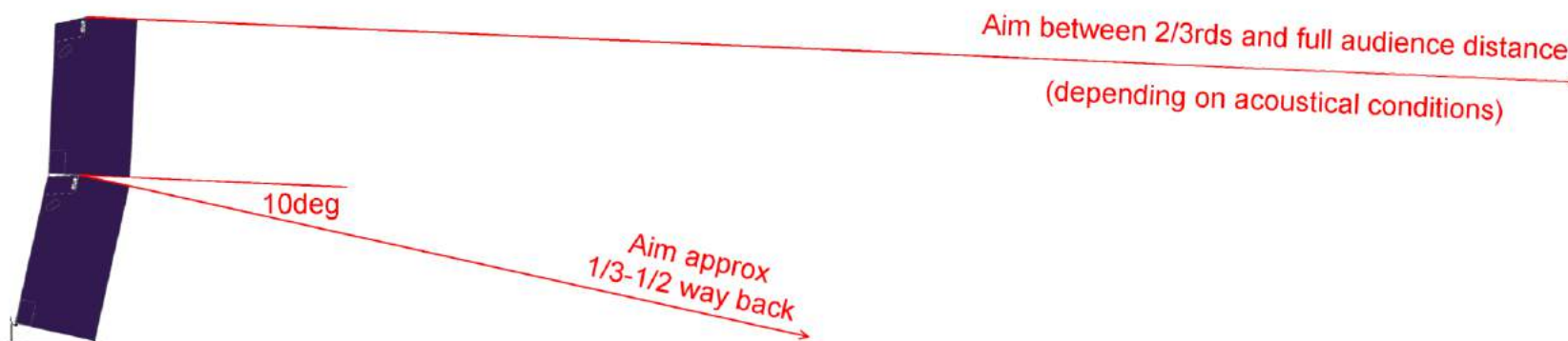


Fig 5.2.3-2 2-high Resolution 4T in a larger club or music venue. The bottom section is aimed between 1/3 & 1/2 way back using an E-Anchor. The top section is aimed between 2/3 & full audience distance using the inter-cabinet Biscomatic adjuster.

Note: Straps (not shown) must be used

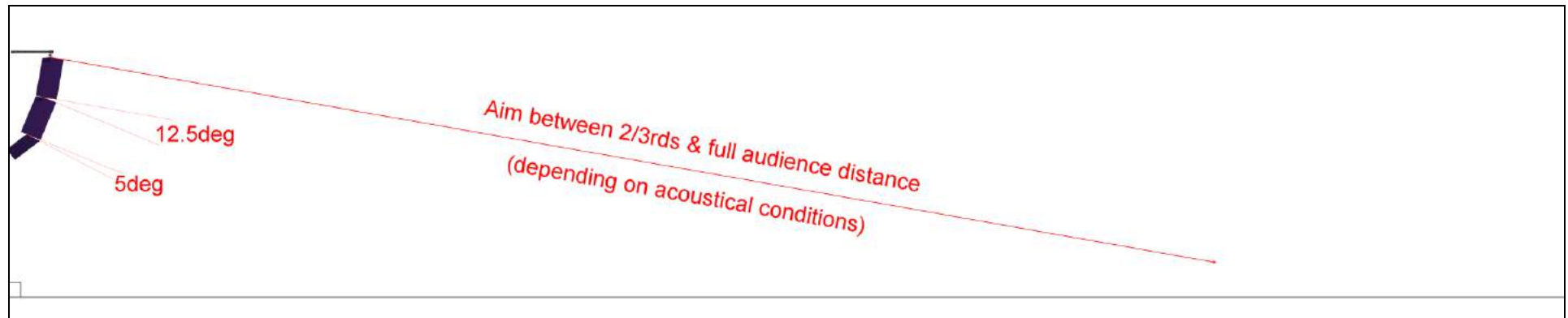
Aiming the top cabinets just short of the furthest audience distance will provide smooth coverage whilst reducing slap-back from far walls. Systems may, of course, be aimed all the way back if the rear of the venue is acoustically absorbent or fitted with diffusers - or if the venue is outdoors.

For normal use, the inter-cabinet angle is best set between 10 and 15° using the Resolution 4T's Biscomatic adjuster. 10° gives very smooth cabinet-to-cabinet transition over a wide audio bandwidth. Inter-cabinet angles less than 10° will give a slight inter-cabinet spl boost.

Flown arrays

Flown arrays must be designed by referring to a sectional view of the venue and adjusting vertical tilt and splay angles for smooth coverage.

Arrays for small flat-floor venues with no bleachers may be tilted to concentrate most of the sound coverage onto the audience areas and to avoid wall reflections.



**Fig 5.2.3-3 Two rows of Resolution 4T + Resolution 4D downfill for a flat-floor venue - tilted to avoid rear wall reflection (Exaggerated for clarity!)
(Note that the outer column hanger points are used to facilitate the tilt)**

As with the stacked examples mentioned earlier, aiming the top cabinets just short of the furthest audience distance will provide smooth coverage whilst reducing slap-back from far walls.

Systems may, of course, be aimed all the way back if the rear of the venue is acoustically absorbent or fitted with diffusers - or if the venue is outdoors.

Inter-cabinet angles between Resolution 4Ts are best set between 7.5 and 15° using the integral Biscomatic adjuster. 12.5° gives very smooth cabinet-to-cabinet transition over a wide audio bandwidth. Inter-cabinet angles less than 12.5° will give a slight inter-cabinet spl boost.

Larger venues with bleachers or balconies may require more cabinets - and with smaller inter-cabinet angles - to cater for the increased vertical coverage and longer throws required. Note that a smaller inter-cabinet angle is also used to cover the difficult floor-bleacher transition.

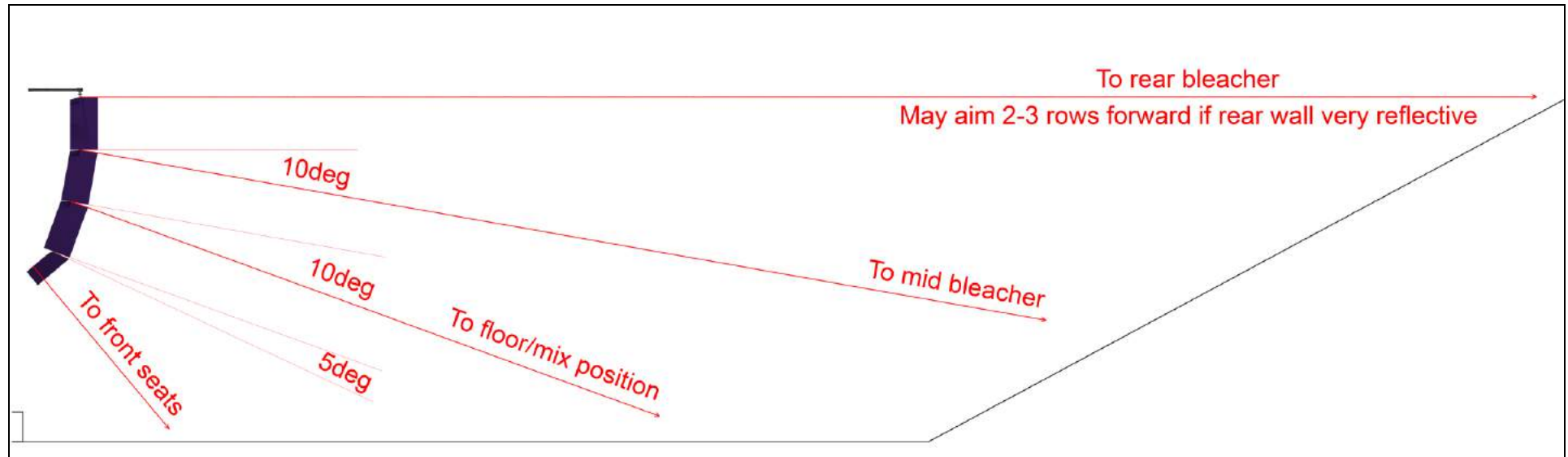


Fig 5.2.3-4 Three rows of Resolution 4T + Resolution 4D downfill for a venue with bleacher seating

As long as the rear seats aren't too high, arrays are often flown at the same height as the uppermost seats. This allows for easy height adjustment by eye.

Inter-cabinet splay angles are set for a smooth inter-cabinet coverage transition to avoid mid-bleacher hot-spots or floor-bleacher transition weak areas.

Note that one row's aim is designated "floor/mix position". When given a choice, most sound engineers tend to prefer their mix position to be on axis of one row of cabinets. Although this is not strictly necessary with correctly splayed Funktion One systems, a designated on-axis position saves unnecessary on-site discussions.

3-wide, 2-deep Resolution 4T array

Typical Resolution 4T array used in combination with a Resolution 5T main systems to cover arena side seating.

3-wide, 2-deep Resolution 4T array (on FG43 grid)

This array uses the horizontal and vertical angle examples shown on the previous few pages.

Horizontal

For this 3-wide example, the horizontal coverage is:

$$50^\circ + (40^\circ + 40^\circ) = 130^\circ$$

Vertical

And the 3-deep + 5° tilted downfill columns give a vertical coverage of:

$$25^\circ + (12.5^\circ) = 37.5^\circ$$

Overall coverage

Overall coverage for this 3-wide, 3-deep array with tilted downfills is:

130° wide x 37.5° deep



Fig 5.2.3-5 3-wide, 2-deep example
(Bridles, safeties & tilting straps not shown)

5.3 Typical bass systems and alignment

Resolution 4 systems are often used with Funktion One F218, F218 + IB218, F121 and F221 bass systems. It is also possible to fly Resolution 18 bass systems with Resolution 4 systems as Resolution 18 systems are dimensionally identical and incorporate the same integral flying system.

Resolution 18 features:

- Identical size to Resolution 4 and 5 for use in arrays
- Funktion One designed Neodymium driver
- Built-in flying hardware
- Supplied with protective wheelboard
- Optional scrim for discrete appearance
- 18" driver
- 40Hz-250Hz Frequency response
- 103dB - 1W at 1m
- 450W AES power
- 8Ω
- NL4 connector & captive lead in cable recess. Driver on 1+/-

F218 features:

- Proven loading design with latest Andrews' tuning
- Funktion One designed drivers
- Integral handles
- Optional throat grilles
- Optional wheels nest inside flare of adjacent enclosure
- Optional lightweight Neodymium magnets
- 2 x 18" drivers
- 45Hz-280Hz Frequency response
- 105dB - 1W at 1m
- 900W AES power
- 2 x 8Ω in parallel = 4Ω
- 2 x NL4 connectors in parallel. One driver on 1+/-, the other on 2+/-



Fig 5.3-1 Resolution 18



Fig 5.3-2 F218

Infrabass 218 features:

- Dual Funktion One designed 18" drivers with 5" voice-coils
- Dimensionally identical to F218
- Includes a curved stainless steel grill
- Integral handles
- Optional wheels
- x 18" drivers
- 20Hz-80Hz Frequency response
- 103dB - 1W at 1m
- 1200W AES power
- x 8Ω in parallel (4Ω)
- 2 x NL4 connectors in parallel. One driver on 1+/-, the other on 2+/-

Infrahorn features:

- Increases efficiency, directivity and projection of a pair of Infrabass (Extra 10dB at 33Hz)
- Optional wheels available



Fig 5.3-3 Infrabass 218



Fig 5.3-4 Infrahorn

F121 features:

- Advanced Andrews' loading
- High output from moderately sized enclosure
- Funktion One designed driver with Neodymium magnet
- Integral handles
- Optional throat grille, wheels and pole mount
- 21" driver
- 40Hz-250Hz Frequency response
- 105dB - 1W at 1m
- 750W AES power
- 4Ω or 8Ω
- 2 x NL4 connectors in parallel. Driver on 1+/-



Fig 5.3-5 F121

F221 features:

- Advanced Andrews' tuning
- Funktion One designed drivers with Neodymium magnets
- Integral handles
- Optional throat grilles
- Optional wheels nest inside flare of adjacent enclosure
- 2 x 21" drivers
- 40Hz-250Hz Frequency response
- 107dB - 1W at 1m
- 1500W AES power
- 2 x 8Ω in parallel = 4Ω or 2 x 4Ω in parallel = 2Ω
- 2 x NL4 connectors in parallel. One driver on 1+/-, the other on 2+/-



Fig 5.3-6 F221

How many?

It's quite usual to use Funktion One bass cabinets and top cabinets on a 1:1 basis, i.e. one dual bass cabinet (F218 or F221) for each Resolution 4 main cabinet. But it really depends on the audience area to be covered and the type of bass response and headroom required.

A 1:1 ratio keeps your F218 or F221 bass system within a dB or two of your Resolution 4's low-mid section sensitivity so the recommended crossover settings in **Section 7.5** will be optimum.

Bass array shapes

For smooth low-mid-to-bass coverage alignment at crossover, it makes sense to:

- Place your bass systems as close as possible to your main arrays - directly beneath the main flown arrays whenever possible
- Make your bass stack width similar to your main array width. Similar widths will provide similar dispersion patterns through crossover. For example 2 x F218 or 2 x F221 wide for a 3 x Resolution 4 width - see below...
- If safety considerations (for example, uneven ground) don't allow bass arrays to be stacked high, you need to spread them considerably wider than the main array. Where your bass system has to be significantly wider than the main array, arrange the bass cabinets in an arc so that they follow the arc of the main array on a common rear point to avoid beaming. They can then be delayed, if necessary, to time and phase align them with the Resolution 4s and will provide a similar dispersion through the crossover region. Also see **Compensating for positional offsets** later...

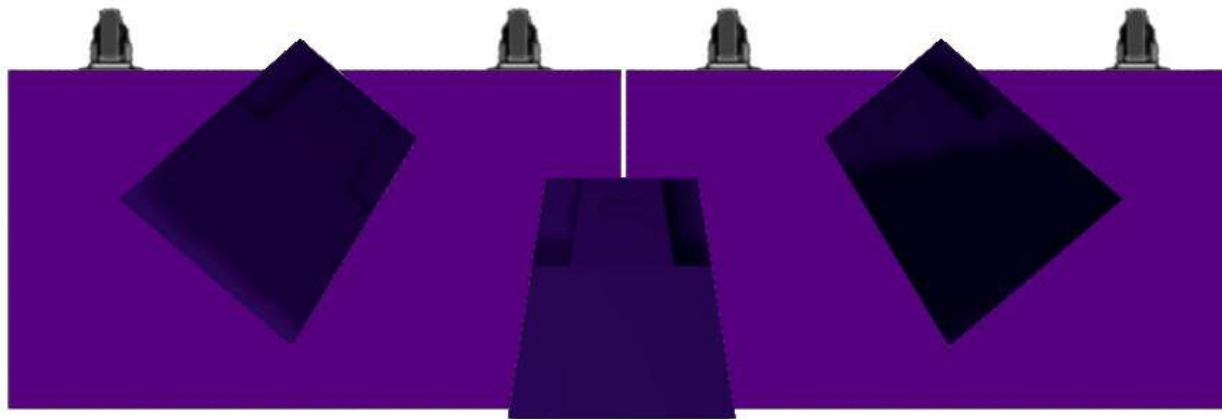


Fig 5.3-7 3 x Resolution 4 array (on FG43 spacing) over 2 x F218 wide bass stack

Smoothing bass coverage

It is always worth allowing for some extra bass cabinets between left and right systems to smooth coverage and avoid a "bass alley" effect up the centre of the venue.

There isn't often a budget for a multitude of closely spaced bass cabinets right along the stage apron – so one solution for smaller stages is to retain some of the bass cabinets from each side and space these inner 2-wide bass arrays equidistant along the stage apron as shown below...

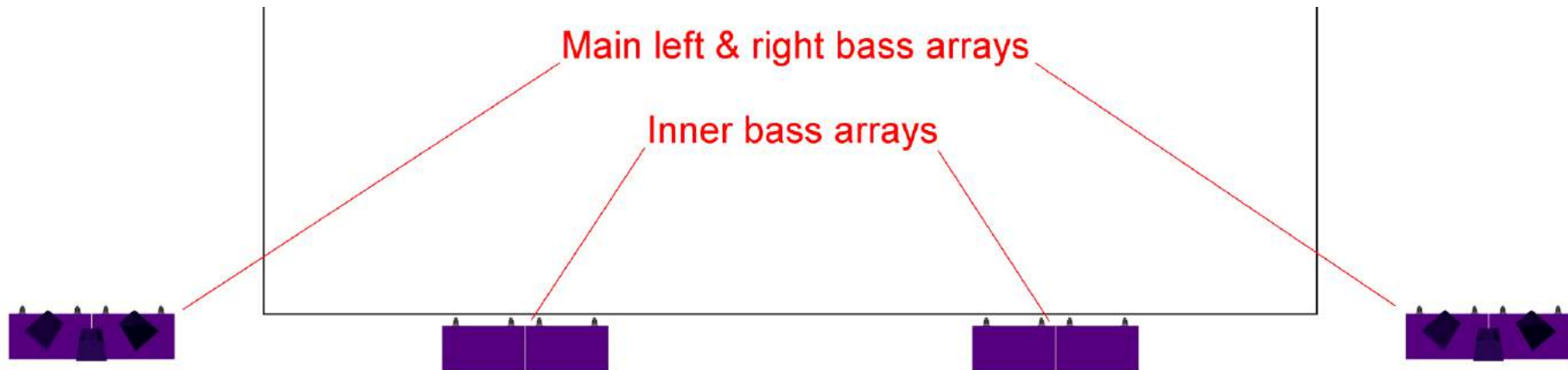


Fig 5.3-8 Inner bass arrays
(They also create handy locations for front fills)

Bass alignment options

It is possible to electronically control the main and inner bass arrays for various coverage and impact options depending on the time alignment applied.

- **Point destination alignment**
Choosing the mix position as the time alignment reference point gives maximum impact at the mix position for bass-loving mix engineers
- **Planar alignment**
Choosing left and right off-centre reference points produces smooth audience coverage and reduces the central peak

Point destination alignment

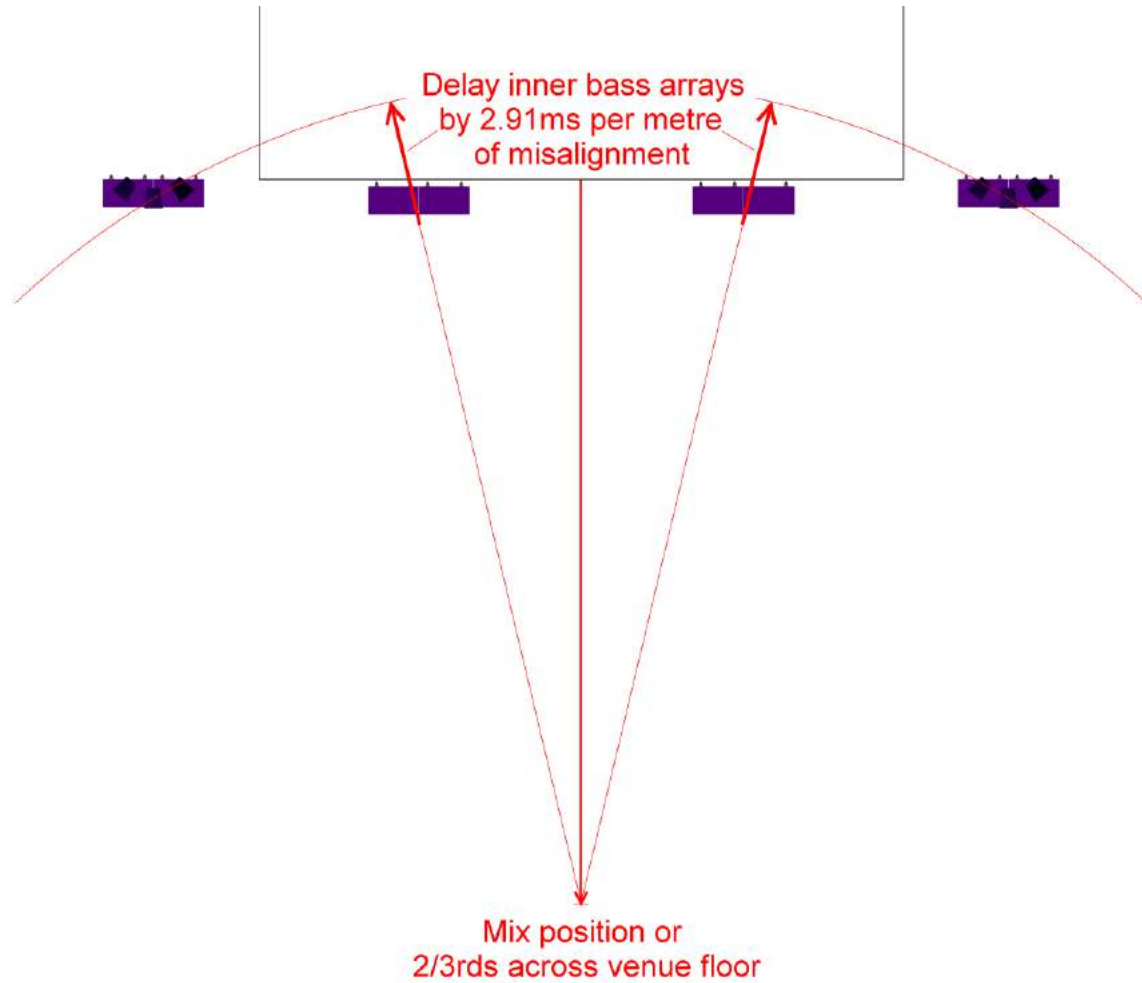


Fig 5.3-9 Mix position alignment provides maximum mix position impact

For larger stages you should probably think about adding a 2-wide splayed block every 6-10m or so. These also provide a handy support for front fills.

Planar alignment

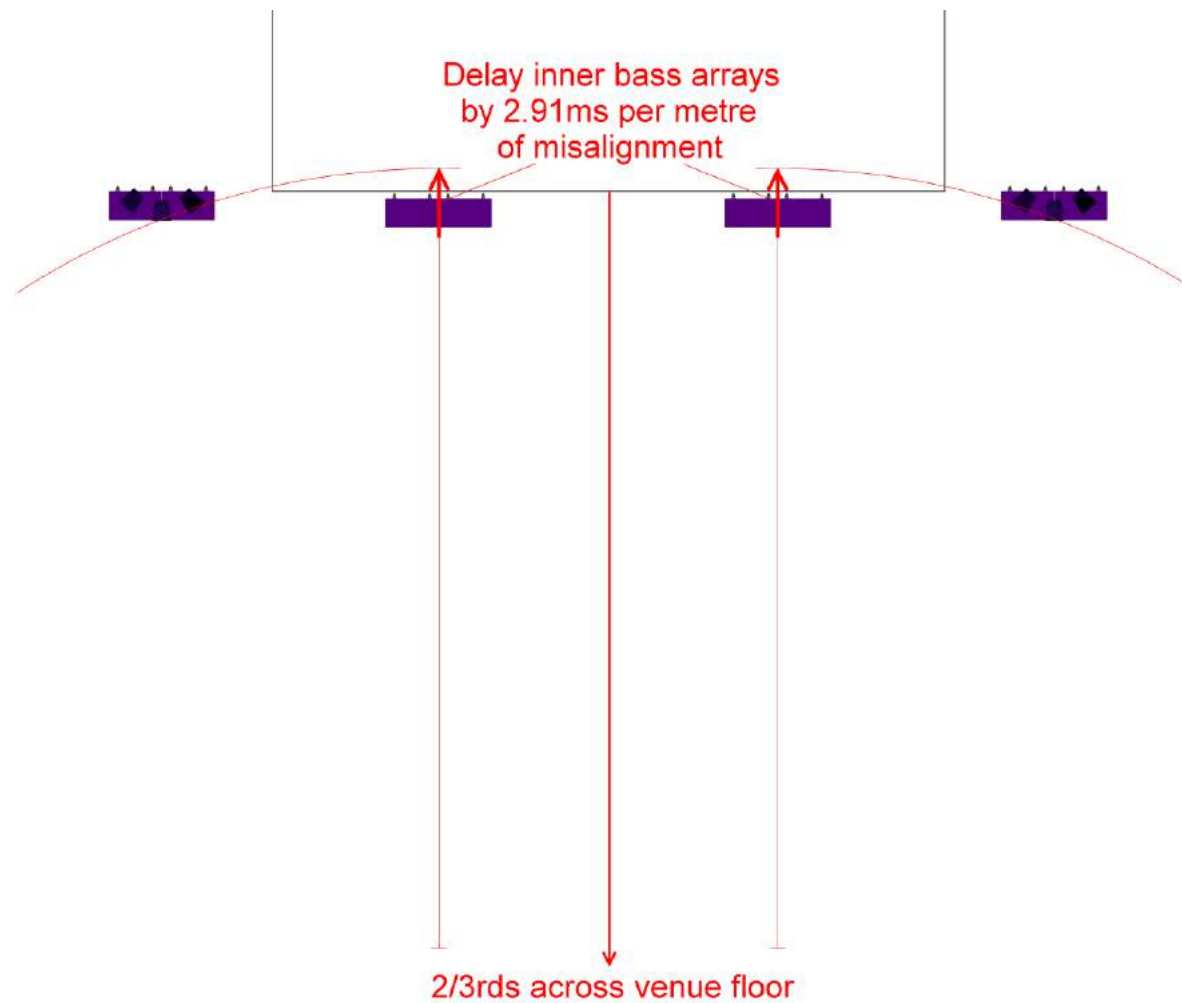


Fig 5.3-10 Off-centre alignment provides smooth bass coverage and reduces the central bass peak

5.3.1 Directional bass arrays and why you may not need to use them

Directional bass arrays should be used with caution. They are rarely required with Funktion One bass systems because Funktion One bass systems are designed for maximum broadband efficiency.

Q. Why is broadband efficiency important?

A. Unfortunately, the answer is a bit drawn out – but please bear with us. We experience the most realistic impact from a sound system when a sound wave effects our whole body, not just our ears. The most effective way of doing this is to design systems to convert as much amplifier power into sound intensity (sound power per unit area) as possible – and over as wide a bandwidth as possible.

*Although sound engineers and manufacturers tend to specify loudspeaker performance in terms of the resulting sound **pressure**, sound power is actually made up of two components; particle velocity and sound pressure. It's analogous to electrical power being the product of current and voltage and time-averaged intensity appears to be important whether you're trying to excite your audience with a larger than life kick drum sound or you're trying to convey plucked strings without running your orchestral reinforcement system into low frequency feedback.*

To get maximum power, the two components (velocity and pressure or current and voltage) need to be in phase over as wide a bandwidth as possible, so resonances must be avoided. And, to achieve maximum power transfer, the source impedance needs to match the load impedance.

There is usually a significant mismatch between the acoustic impedances (pressure ÷ velocity) of direct radiating loudspeakers and the all-important air that conveys the loudspeaker signal to the audience but the match can be improved with careful loudspeaker design, especially if horn-loading is used, as the horn will act like a matching transformer.

The increasing availability of high power amplifiers and the improvement in loudspeaker materials has led many manufacturers to abandon their quest for efficiency. Unfortunately, these inefficiencies can't simply be overcome by applying more power so the current trend isn't very clever.

We hear sound pressure, but that sound pressure is caused by the sound power that's transferred to us. If the power transfer is inefficient, that important pressure-velocity relationship is compromised and the resultant sound pressure will lack impact. This can often be seen as excessive phase vs frequency changes over the system bandwidth – over and above the usual boundary and distance effects. It's why horn loaded mid-bass systems tend to have more impact than direct radiating systems – even if both systems are tweaked for identical amplitude responses.

Most sound engineers will attempt to get the impact they want by driving an inefficient (and already heavily powered) bass system even harder – either by turning it up, tweaking the eq., or a combination of both. This causes more leakage behind the system and has led to the current popularity of cardioid bass configurations.

Cardioid bass configurations are obviously going to be popular with a lot of loudspeaker manufacturers as they can generate extra profits by selling you more speakers to deal with the adverse effects of having to drive their systems so hard in the first place. And power amplifier manufacturers probably can't believe their luck!

However, if you still feel you must use a directional bass array to deal with local anomalies, please be aware of the following pros and cons...

5.3.2 Types of cardioid/end-fired systems & their pros and cons

There are two main types of popular directional systems but very few users seem to understand their pros and cons.

Reversed and delayed rear cardioids

This is the most popular set-up - but not necessarily the best as has some draw-backs for as far as audience sound is concerned.

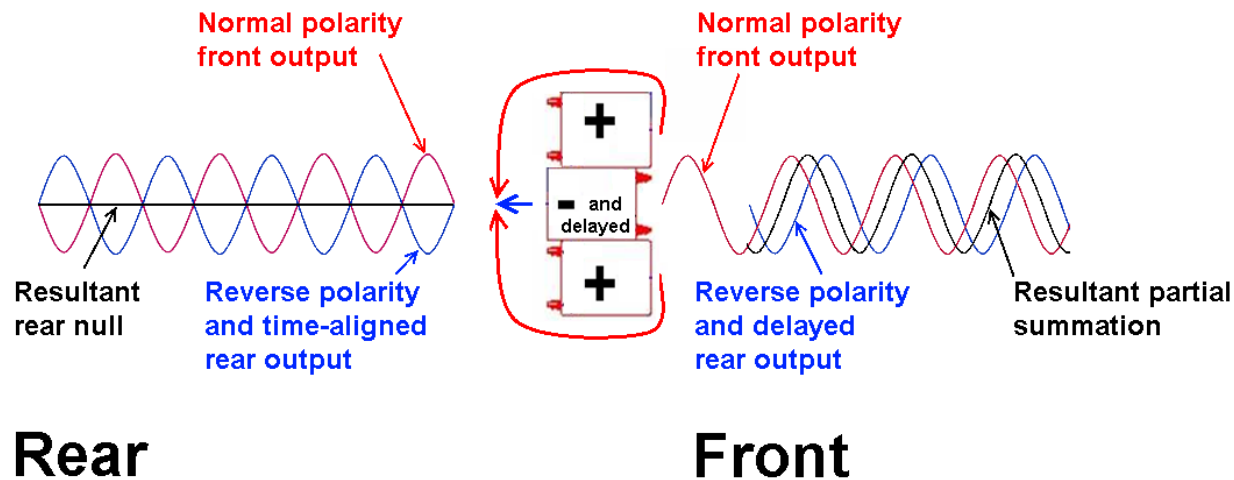


Fig 5.3.2-1 Configuration for best rear cancellation

Important note!

Although this polarity-reversed cardioid configuration gives the best rear cancellation - the front-to-back ratio is usually 15-20dB over a broad frequency range - it compromises audience impact due to its inferior attack and its inferior forward summation at the upper and lower cut-off frequencies.

A better in-phase, end-fired cardioid arrangement will give reasonable rear bass suppression can be achieved without compromising audience impact.

Read on...

In-phase end-fired cardioids

This alternative cardioid/end-fired set-up provides better, broad-band audience impact.

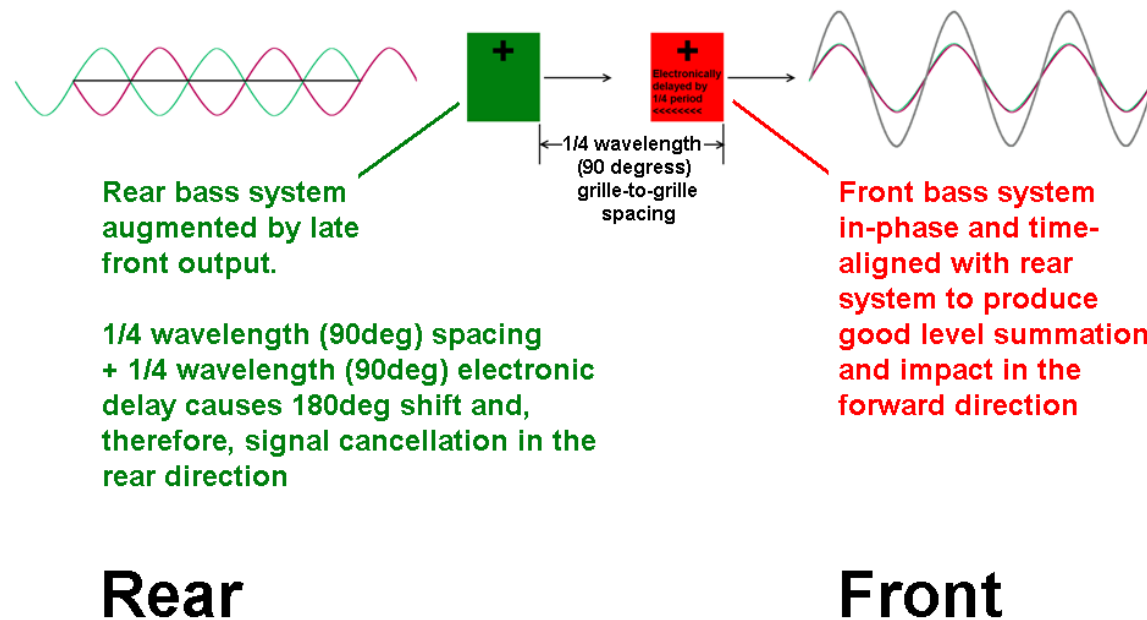


Fig 5.3.2-2 Configuration for best audience impact

This in-phase deployment gives the best forward impact and bandwidth – but at the expense of rear cancellation.

Front-to-back ratio is usually around 15dB at the spacing/delay frequency but tends to be more frequency dependent than a classic, polarity-reversed cardioid – reducing to 5-6dB or less towards the lower and upper cut-off frequencies. But note the improved forward characteristic!

This is the preferred configuration for good audience impact.

5.3.3 Compensating for positional offsets

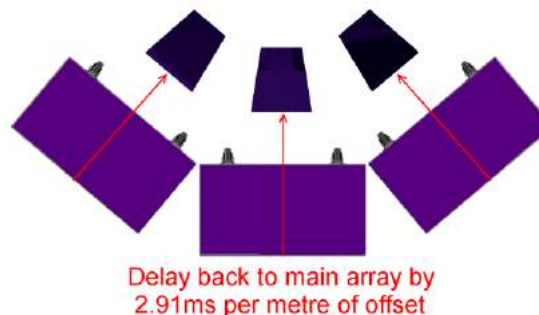


Fig 5.3.3-1 Positional compensation (Extreme example for illustration only!)

There are two distinct stages to delay-aligning bass and main systems successfully.

1) **Physical offset/time alignment**

Measure the relative distances to the bass and main systems from a representative position in the room - usually the mix position, but, if there is no auditorium mix position, 2/3rd across the audience or dance floor area - and delay the required section by 2.91ms for every metre of physical offset.

2) **Phase alignment - at the representative listening position (usually the mix position)**

This fine adjusts for phase shifts and their resultant group delays. This can be caused by bass enclosure physics, crossover topologies and/or sound reflecting off nearby boundaries, arriving late and vector summing with the direct sound to create an overall phase lag.

Note that the above time alignment must be done first.

If you jump straight in with phase alignment, before you've compensated for physical offsets, you could end up a whole cycle out at crossover!

It's also worth checking your signal paths (amplifier, controller settings etc) to make sure everything is in-phase before you start.

- a) Set up a pink noise or musical signal through a graphic equaliser with all its bands fully attenuated except the bass-main crossover frequency - set the crossover frequency slider to full boost. Make sure you use this 1/3 octave signal and not a sine wave oscillator...
- b) Using this crossover-tuned signal, switch between your main and bass systems and balance their levels.
- c) Now **temporarily** switch the bass system out of phase and, with both main and bass systems on, fine adjust the delay for a null in level.
(Note that you are unlikely to hear a complete cancellation in a real room)
- d) Now - **and this is most important** - switch the bass system back to the correct polarity!!!

6 Connector pin-outs and cables

6.1 EP-6 connector pin-outs

Resolution 4T, 4E and 4D

The Resolution 4T and 4E systems employ Amphenol EP series connectors.

- The captive inter-cabinet/input lead connector is an EP-6-12 6-pole nickel finish male line plug
- The chassis link out connector is an EP-6-13P 6-pole nickel finish female chassis socket

EP-6 pin configurations

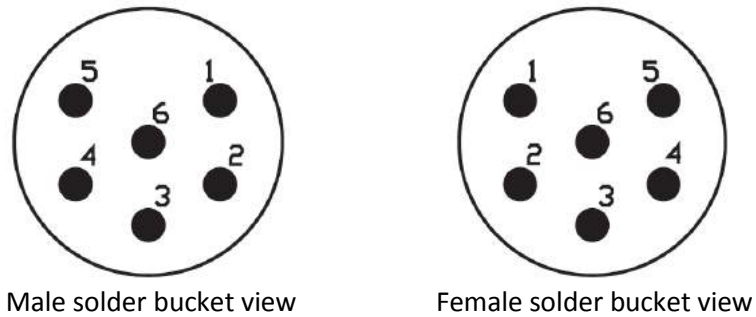


Fig 6.1-1 EP-6 connector pin-out

Resolution 4T and 4E

Pin	Function	Driver terminal
1	Low-mid	12" -ve
2	Low-mid	12" +ve
3	High-mid	8" -ve
4	High-mid	8" +ve
5	High	1" -ve
6	High	1" +ve

Fig 6.1-2 Resolution 4T/4E pin-out

Resolution 4D

Pin	Function	Driver terminal
1	Link through	Link through
2	Link through	Link through
3	High-mid	8" -ve
4	High-mid	8" +ve
5	High	1" -ve
6	High	1" +ve

Fig 6.1-3 Resolution 4D pin-out

(For bass system NL4 pin-outs, see features lists in previous section)

6.2 Recommended cables

Funktion One loudspeaker systems do not require particularly exotic cables. Standard pro-audio copper core loudspeaker cables are usually oxygen-free and perfectly suitable for this application.

Good touring examples are:

3-way Resolution 4/5 series

- 6-core 2.5mm² tour grade multi-core loudspeaker cable for 3-pair EP6 cables
- 18-core 2.5mm² tour grade multi-core loudspeaker cable for 6 x 3-pair cables (typically using 19-pin Socapex connectors)

Single-driver Bass systems - Resolution 18, F118, F121

- 4-core 2.5mm² tour grade multi-core loudspeaker cable for single-pair NL-4 bass cables (2 x 2.5mm² cores used in parallel)

Dual-driver Bass systems - F215, F218, F221, Infrabass 218

- 4-core 4mm² tour grade multi-core loudspeaker cable for 2-pair NL-4 bass cables

A good example of installation speaker cable is:

- Install grade loudspeaker cable LSZH
(For installations in public buildings, clubs and cruise ships where Low Smoke Zero Halogen cables are specified. These cables are compliant with IEC60092, IEC60332.1, IEC60332.3C, IEC60754.1, IEC60754.2 and IEC60134.2)

Low loss cable runs

The following table gives the maximum cable lengths allowable to keep level losses below 0.6dB.

Copper core cross sectional area mm ²	Nearest suitable AWG size	8 ohm load Single Low-mid or 2 x linked High-mids or 2 x linked Highs metres (ft)	4 ohm load 2 x linked Low-mids or 4 x linked High-mids or 4 x linked Highs metres (ft)
2.50 mm ²	13awg	36m (118ft)	18m (59ft)
4.00 mm ²	11awg	58m (190ft)	29m (95ft)

Fig 6.2-1 Cable runs

6.3 Loudspeaker polarity

Loudspeaker cones and diaphragms create sound by moving in and out to modulate air pressure and velocity. It is important that all loudspeakers in a sound system move in the same direction when driven in unison. In other words, they should all have the same polarity.

Same polarity (“in phase”)

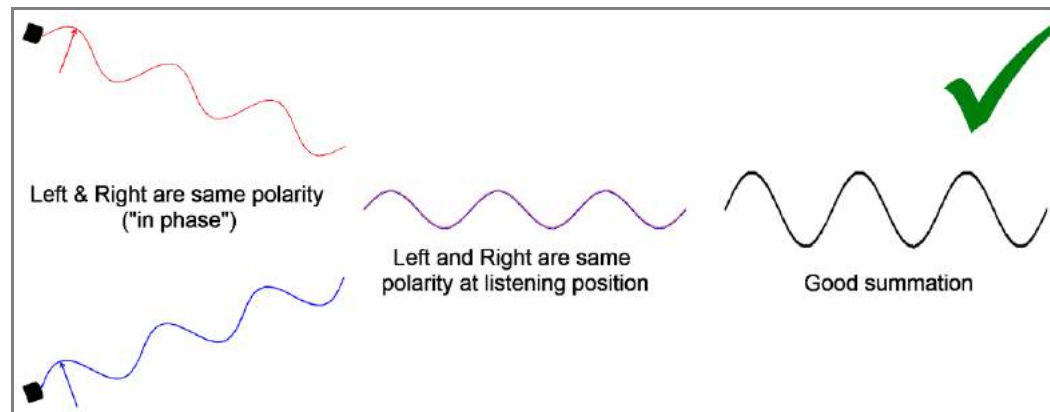


Fig 6.3-1 In-phase summation

Loudspeakers with the same polarity will give:

- Good bass extension
- Good bass impact
- Good “between the speakers” stereo imaging with a smooth central transition
- Solid centre-panned vocal imaging

Opposite polarity (“out of phase”)

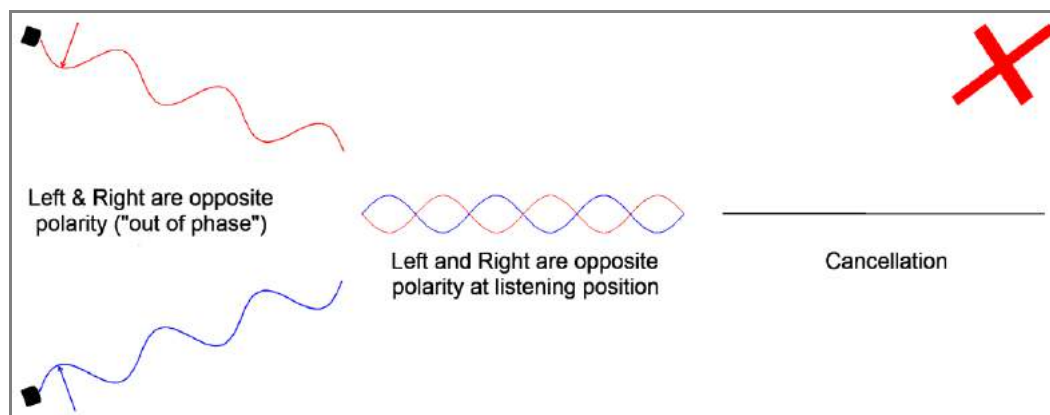


Fig 6.3-2 Out-of-phase cancellation

Loudspeakers with opposing polarities will give the following, depending on which section (bass, low-mid, high-mid or high) is incorrectly set up:

- Poor bass extension
- No bass impact
- Poor “between the speakers” imaging. Just hard left or hard right “distant” effects
- No solid central vocal image. Centre-panned vocals will sound indistinct or thin and, again, the “distant” effect will be evident.

It is usually fairly easy to ensure that your loudspeakers are wired to the same polarity if all your loudspeakers are being driven via identical signal paths and equipment. Simply check that the same loudspeaker cable core colours are wired to the same + or – pins at the amplifier end and at the loudspeaker connector end.

If you cannot be certain that your signal paths are identical – you may be using a mix of old and new equipment or equipment from different manufacturers, for instance – it makes sense to check out the system using a polarity checker.

A good polarity checker, such as the Funktion One ASPC1, will allow you to check not only your amplifier-loudspeaker combinations but also the entire signal path including mixers and crossover connections.

Introducing the Funktion One Audio Systems Polarity Checker (ASPC1)

Pulse generator

- XLR pulse generator output
- LED pulse indicator

Detector

- Built in microphone
- LED polarity indicators

General

- Belt pouch included
- Batteries included
- User Instruction Card



Fig 6.3-3 Funktion One polarity checker

The ASPC1 is a two-part system comprising a pulse generator and a detector. The pulse generator allows you to inject a special test signal anywhere in the signal path whilst the detector microphone lets you check the resulting loudspeaker polarity acoustically. See the ASPC1 user guide for more information.



Absolute polarity and live sound

Maintaining absolute polarity through a sound system means not only making sure all your loudspeakers are “in phase” but also ensuring that your microphones give a positive-going output voltage for a positive-going pressure, that there are no polarity reversals anywhere in the signal path and that your loudspeaker systems provide a positive pressure in response to that positive-going signal.

Many natural sound sources, especially percussion and vocals, produce asymmetrical waveforms. It makes sense to ensure that a positive-going percussive impact creates a positive-going pressure for the audience to maintain that all-important bodily impact. Some recording engineers are also adamant that vocals overlay the band more clearly if absolute polarity is maintained.

Common sense, then, suggests that, as long as we’re using polarity-matched microphones and well-documented signal paths, why not maintain absolute polarity – if only for consistency?

7 Amplification and control

7.1 Electrical and fire safety



Qualified and experienced system technicians only

Funktion One Resolution 4 series loudspeakers are high power systems and should only be powered from professionally assembled, PAT tested amplifier racks designed and installed by fully experienced system technicians.

The following information is intended to be used by fully qualified personnel only.

Cabling

- Use only Funktion One recommended loudspeaker connectors wired so that the cables have adequate strain relief for their intended purpose and so that conductors are fully shrouded
- Use the appropriate cable conductor gauge. **See section 6.2**
- Ensure that your cables are in good condition and free from damage
- Ensure that there are no loose conductor strands to short out and create a fire hazard
- If you re-use older cables, strip them back a little, wherever possible, to expose clean conductor ends that are free from corrosion
- Use fire retardant or low emission cables where these have been specified by the contract or by local safety regulations
- Keep connectors away from flammable furnishings as connectors can get hot under fault conditions

Amplification

- We suggest electronically limiting maximum long-term and peak amplifier power to comply with the system's maximum power ratings. **See section 3.2**
- Remember that heavily clipped signals can double a power amplifier's output. **See appendix A**
If heavily clipped signals are expected due to equipment with inadequate headroom in the signal path, inexperienced operators etc., set rms and peak output limiter thresholds 3dB below the loudspeaker's AES ratings. **See sections 7.6 & 7.7**
- Keep amplifier racks properly ventilated and well away from flammable furnishings

General

- There are no user-serviceable parts inside your Resolution 4 system. Refer servicing to Funktion One approved service facilities only. Contact Funktion One if in doubt

7.2 Choosing a power amplifier

Long-term power ratings

Modern loudspeaker drivers are specified to an AES standard. This specifies their long-term (typically 2 hour) band-limited AES power rating. The band limits are usually chosen to match the drivers' intended use via a suitable crossover system.

Peak power ratings

The AES band-limited test signal has a 6dB crest factor so loudspeaker drivers are usually specified with a peak power rating that can be up to 4 times their AES power rating if suitable limiting is in place to prevent peak power occurring for long enough to overheat their voice coils.

Amplifier power and limiters

Best practice is to specify amplifiers that are capable of delivering the driver's peak power rating (the higher figure in the following tables) but to set long-term limiters to the driver's AES power rating. This may be done using the **Funktion One X02, X04 or X04A** Audio Management Systems.

- Click on the product type (above) for further product information -

A further enhancement is to use both long-term and peak limiters. The long-term limiter is set to the driver's AES power rating and an additional look-ahead peak limiter (e.g. the D-Max clip limiter in the **Funktion One X04 or X04A** Audio Management System) is set to the amplifier's peak output, or to 6dB above the long-term limiter, whichever is the lowest. This will protect the driver from being overdriven on peaks whilst preventing audible clipping.

It is ok to set limiters below the driver's power ratings - to maintain spectral balance at limiting, for instance - but limiters must never be set above the Funktion One on-line calculations.

See **Sections 7.6 and 7.7**.

Recommended power ranges

Always use Funktion One loudspeaker management systems with correctly set crossovers filters and limiters. *See sections 7.5 - 7.7.*

The following tables show recommended power ranges. The lower figure in each case is the power required to meet the driver's AES power rating. The upper figure in each case is the power required to meet the driver's peak power rating.

- Always use long-term limiters set to suit the driver's AES power. This will prevent extended periods of over-powering or clipping but still allow peak signals to be passed unhindered
- Choose power amplifiers capable of delivering the upper figure where budgets allow. This will prevent the amplifier running out of headroom before peak performance is reached
- Use look-ahead peak limiters (e.g. the D-Max clip limiters in the Funktion One XO4) if they are available

See *Sections 7.6 and 7.7* for more information on limiters

Note

Unless otherwise stated, power ratings in this section are average power (rms voltage x rms current – sometimes called "rms power").

Resolution 4T, 4E & 4S systems

Section	Power into 16 ohms	Power into 8 ohms	Power into 4 ohms
12" Low-mid	-	300 - 1,200W	600 - 2,400W
8" High-mid	200 - 800W	400 - 1,600W	800 - 3,200W
1" High	50 - 200W	100 - 400W	200 - 800W

Fig 7.2-1 Resolution 4T, 4E & 4S power ratings

Resolution 4D downfill systems

Section	Power into 16 ohms	Power into 8 ohms	Power into 4 ohms
8" High-mid	200 - 800W	400 - 1,600W	800 - 3,200W
1" High	50 - 200W	100 - 400W	200 - 800W

Fig 7.2-2 Resolution 4D power ratings

7.3 Recommended Funktion One power amplifiers

Note

- The Funktion One XO4 loudspeaker management system (with D-Max peak limiting) is recommended for optimal system control
- E-series and F-series amplifiers have opposing airflows. If E-series and F-series amplifiers are mounted in the same rack, always place the F-series at the top to ensure correct ventilation

Resolution 4T, 4E & 4S systems

- Click the amplifier columns (below) for further product information -

Section	E-series power amplifiers	F-series power amplifiers
12" Low-mid	E45 (2-ch amplifier)	F100-2 (2-ch amplifier)
	E100Q (4-ch amplifier)	
8" High-mid	E45 (2-ch amplifier)	F100-2 (2-ch amplifier)
	E100Q (4-ch amplifier)	
1" High	E15 2-ch amplifier	F40Q (4-ch amplifier)
	E30Q 4-ch amplifier	

Fig 7.3-1 Resolution 4T, 4E & 4S amplifier recommendations

Notes

The power amplifier model chosen to drive the Low-mid and High-mid sections may also be used to drive the High section as long as suitable long-term and peak (D-Max) limiters are set using a Funktion One XO4 loudspeaker management system.

Resolution systems are an easy load for most amplifiers due to their high in-band impedances so up to five cabinets may be linked in parallel.

Resolution 4D downfill systems

Section	E-series power amplifiers	F-series power amplifiers
8" High-mid	E45 (2-ch amplifier)	F100-2 (2-ch amplifier)
	E100Q (4-ch amplifier)	
1" High	E15 2-ch amplifier	F40Q (4-ch amplifier)
	E30Q 4-ch amplifier	

Fig 7.3-2 Resolution 4D amplifier recommendations

7.3.1 Amplifier output pin-outs

Funktion One amplifier type	Amplifier socket Function	Speakon connector pin	Recommended cable plug & notes
E15, E45 or E90 2-ch amplifier	Channel A out		
	Ch A	1+	NL2 - Ch A only on 2-pole connector
		1-	
	Channel B out		
	Ch B	1+	NL2 - Ch B only on 2-pole connector
		1-	
	Bridge/stereo out	(Stereo mode)	(Make sure amplifier is in stereo mode)
	Ch A	1+	NL4 - Chs A & B on same 4-pole connector
	1-		
Ch B	2+		
	2-		
E30Q, E100Q or F40Q 4-ch ampl.	Channel A out		
	Ch A out	1+	NL2 - Ch A only on 2-pole connector or... NL4 - Chs A & B on 4-pole connector
		1-	
	Ch B out	2+	
		2-	
	Channel B out		
	Ch B	1+	NL2 - Ch B only on 2-pole connector
		1-	
	Channel C out		
	Ch C out	1+	NL2 - Ch C only on 2-pole connector or... NL4 - Chs C & D on 4-pole connector
		1-	
	Ch D out	2+	
	2-		
Channel D out			
Ch D	1+	NL2 - Ch D only on 2-pole connector	
	1-		

Fig 7.3.1-1 Funktion One E-series and F40Q power amplifier output pin-outs

Funktion One amplifier type	Amplifier socket Function	Speakon connector pin	Recommended cable plug & notes
F100-2 2-ch amplifier	Channel A out		
	Ch A	1+, 2+	NL2 - Ch A on 2-core cable (+ve on 1+, -ve on 1-) ...or... NL4 - Ch A on 4-core cable (+ve on 1+ & 2+, -ve on 1- & 2- to reduce cable impedance)
		1-, 2-	
	Channel A parallel		
	Ch A	1+, 2+	NL2 - Ch A on 2-core cable (+ve on 1+, -ve on 1-) ...or... NL4 - Ch A on 4-core cable (+ve on 1+ & 2+, -ve on 1- & 2- to reduce cable impedance)
		1-, 2-	
	Channel B out		
	Ch B	1+, 2+	NL2 - Ch A on 2-core cable (+ve on 1+, -ve on 1-) ...or... NL4 - Ch A on 4-core cable (+ve on 1+ & 2+, -ve on 1- & 2- to reduce cable impedance)
		1-, 2-	
Channel B parallel			
Ch B	1+, 2+	NL2 - Ch A on 2-core cable (+ve on 1+, -ve on 1-) ...or... NL4 - Ch A on 4-core cable (+ve on 1+ & 2+, -ve on 1- & 2- to reduce cable impedance)	
	1-, 2-		

Fig 7.3.1-1 Funktion One F100-2 power amplifier output pin-outs

7.4 Rack patch examples with Funktion One XO2 or XO4/4A control

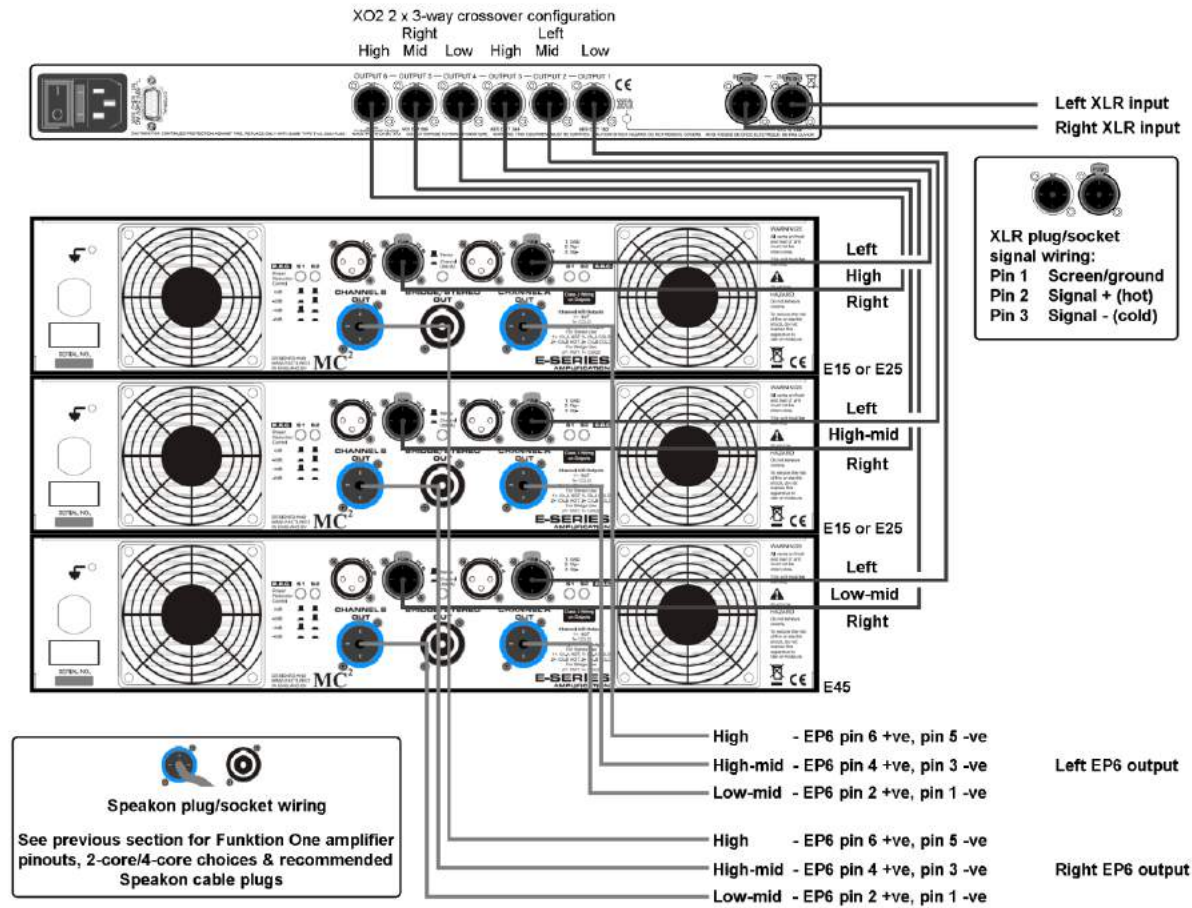


Fig 7.4-1 Resolution 4 rack schematic using XO2 controller and E-series amplifiers - rear view
(Each amplifier outlet can drive up to five Resolution 4 series cabinets)

All of these rack layout examples follow the loudspeaker topology and left-right deployment. For instance, the first example (above) has the low-mid amplifier at the bottom, the high-mid in the centre and the high amplifier at the top. It also has the left controls on the front left and the right controls on the front right.

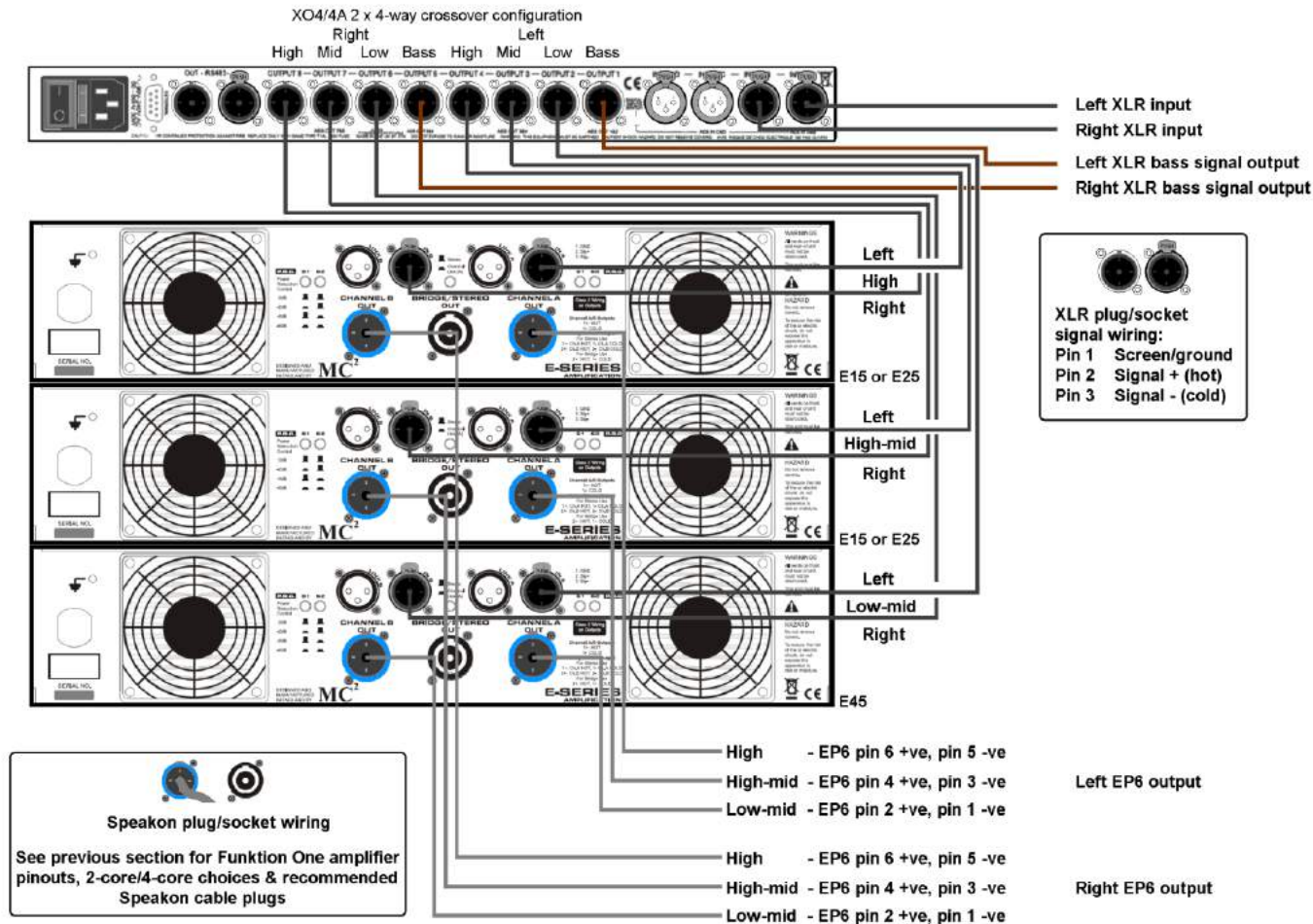
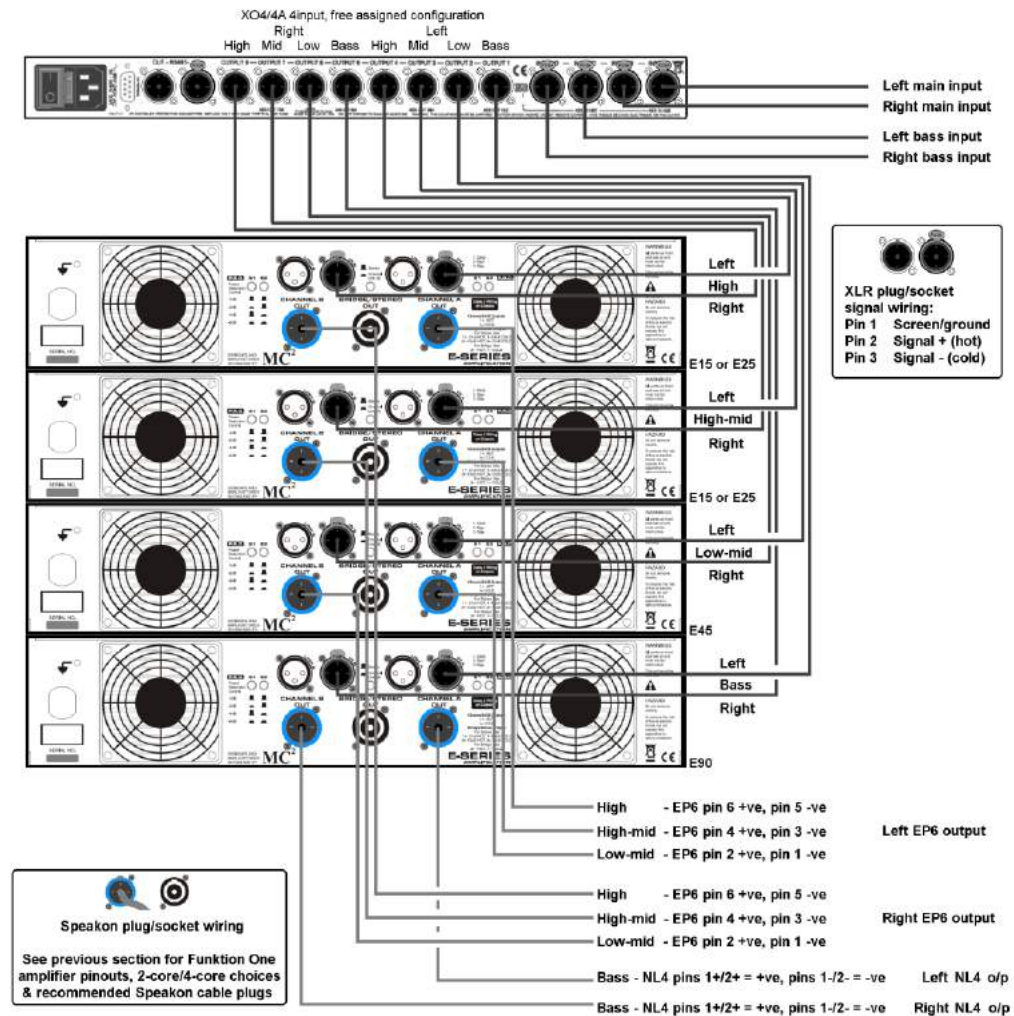


Fig 7.4-2 Resolution 4 rack schematic using XO4/4A controller and E-series amplifiers - rear view
(Each amplifier outlet can drive up to five Resolution 4 series cabinets)

The 8-output XO4 or XO4A is set up for 2 x 4-way crossovers. Bass signals on outputs 1 and 5 are made available on IO panel XLRs. *See panel example here.*



**Fig 7.4-4 Resolution 4 (+ bass) rack schematic using XO4/4A controller and E-series amplifiers - rear view
(Each amplifier outlet can drive up to five Resolution 4 series cabinets)**

This configuration allows operators to develop separate bass mixes, allowing some instruments mics prone to LF feedback to be kept out of the bass mix. Note that the auxiliary bass mix output level must be calibrated for optimum Resolution 4 - to - bass system alignment.

Panel kits

Funktion One panel kits are available prewired for a wide variety of loudspeaker combinations.

The system is based on a standard panel that is populated as required.

The fully populated example shown in the photograph (right) has:

- XLR data in & out - for AudioCore control, for example
- Four controller line input with through-links
- Two controller line outputs - for a bass slave rack, for example
- Six 2-way NL4 speaker outlets - sourced from a combination of 2-way (NL4) & 1-way (NL2) amplifier outputs
- Left and right 3-way EP6 speaker outlets

Contact your distributor or dealer to discuss your preferred panel facilities.



Fig 7.4-5 Typical Funktion One panel kit

7.5 Crossover settings

See next section for limiter settings.

The following tables list the recommended crossover filter and relative gain settings for Resolution 4 series system and the Resolution 4D downfill when used with F118/218, Resolution 18 or F121/221 bass systems.

These settings can also be found on the Funktion One web site.

Check:

- www.funktion-one.com/crossover-settings/resolution-5/ for the latest Resolution 4 settings
- www.funktion-one.com/crossover-settings/resolution-4/ for the latest Resolution 4 settings

Resolution 4T, 4E and 4S with F218 or Resolution 18 - with or without the optional Infrabass (Infrabass settings in red)

Resolution 4T, 4E & 4S tri-amped	Delay (mS)	Polarity	High Pass Freq (Hz)	High Pass Type	Low Pass Freq (Hz)	Low Pass Type	Relative Gain (dB)
<i>Optional Infrabass 218</i>	<i>6</i>	<i>+</i>	<i>20</i>	<i>24dB But</i>	<i>45</i>	<i>24dB LR</i>	<i>+10</i>
F218 or Resolution 18	0	+	20 (no Infrabass) <i>45 (with Infrabass)</i>	24dB But <i>24dB LR</i>	114	24dB LR	+8
12"	1.500	+	114	24dB LR	445	24dB LR	+5
8"	3.390	+	445	24dB LR	5k77	24dB LR	0
1"	3.632	-	5k55	24dB LR	32k	24dB LR	-3
<i>(Resolution 4D also uses above 8" & 1" settings when used with F118/F218)</i>							
Resolution 4T, 4E & 4S bi-amped (passive HF)	Delay (mS)	Polarity	High Pass Freq (Hz)	High Pass Type	Low Pass Freq (Hz)	Low Pass Type	Relative Gain (dB)
18"	0	+	20	24dB But	114	24dB LR	+8
12"	1.500	+	114	24dB LR	445	24dB LR	+5
8" + 1"	3.390	+	445	24dB LR	32k	24dB LR	-1

Fig 7.5-1 Resolution 4T, 4E and 4S crossover settings for use with F118, F218, Resolution 18 and Infrabass

Resolution 4T, 4E and 4S with F121/221 bass system

Resolution 4T, 4E & 4S tri-amped	Delay (mS)	Polarity	High Pass Freq (Hz)	High Pass Type	Low Pass Freq (Hz)	Low Pass Type	Relative Gain (dB)
21"	0	+	20	24dB But	125	24dB LR	+8
12"	2.000	+	125	24dB LR	445	24dB LR	+5
8"	3.890	+	445	24dB LR	5k77	24dB LR	0
1"	4.132	-	5k55	24dB LR	32k	24dB LR	-3
<i>(Resolution 4D also uses above 8" & 1" settings when used with F121/F221)</i>							
Resolution 4T, 4E & 4S bi-amped (passive HF)	Delay (mS)	Polarity	High Pass Freq (Hz)	High Pass Type	Low Pass Freq (Hz)	Low Pass Type	Relative Gain (dB)
21"	0	+	20	24dB But	114	24dB LR	+8
12"	2.000	+	114	24dB LR	445	24dB LR	+5
8" + 1"	3.890	+	445	24dB LR	32k	24dB LR	-1

Fig 7.5-2 Resolution 4T, 4E and 4S crossover settings for use with F121 and F221

7.6 Limiter settings - including on-line calculator

Initial limiter settings for amplifiers with industry standard 32dB voltage gain

The following tables list the recommended limiter settings for Resolution 4 series systems and Resolution 4D downfills when used with power amplifiers set for the industry standard gain of 32dB:

Note!

Always check your power amplifier's specifications and settings before assuming it is 32dB.

Limiter setting for amplifiers with 32dB gain

Resolution 4T, 4E & 4S	Main long-term limit threshold (dBu)	Attack/ decay for XO series controller	D-Max clip limiter for XO series controller (dB over)
12"	+4dBu	Auto	+6dB
8"	+5dBu	Auto	+6dB
2 x 1"	-1dBu	Auto	+6dB
Resolution 4D	Main long-term limit threshold (dBu)	Attack/ decay for XO series controller	D-Max clip limiter for XO series controller (dB over)
8"	+5dBu	Auto	+6dB
1"	-1dBu	Auto	+6dB

Fig 7.6-1 Resolution 4T, 4E and 4S limiter settings for amplifiers with 32dB gain

Initial limiter settings for amplifiers with other voltage gains - using the Funktion One on-line calculator

Recommended limiter settings for Resolution 4 series systems and Resolution 4D downfills used with power amplifiers with other voltage gain settings can be obtained using Funktion One's on-line calculator.

If you're on line, simply go to <http://www.funktion-one.com/settings/> and then scroll down for the Limiter Setting Calculator ↓

LIMITER SETTING CALCULATOR

ENTER DETAILS:

Driver / Loudspeaker RMS power (AES) W

Driver / Loudspeaker impedance Ω

No. of Drivers / Loudspeakers (in parallel)

Amplifier Gain dB

▶ CALCULATE

Limiter setting*

Total Driver/Loudspeaker impedance

Fig 7.6-2 On-line limiter calculator

Once you're at the Calculator part of the Funktion One page, enter the relevant figures into the left hand column and click **Calculate**. The recommended limiter setting and total load impedance presented to the power amplifier will be indicated in the right hand windows. See following example...

Example

LIMITER SETTING CALCULATOR	
ENTER DETAILS:	
Driver / Loudspeaker RMS power (AES)	300 W
Driver / Loudspeaker impedance	8 Ω
No. of Drivers / Loudspeakers (in parallel)	1
Amplifier Gain	32 dB
▶ CALCULATE	
Limiter setting*	4 dB
Total Driver/Loudspeaker impedance	8 Ohms

Fig 7.6-3 On-line limiter calculation

Figures for Resolution 4 Low-mid must be entered on the left. Limiter setting and impedance will appear on right after **Calculate** is clicked.

Note again!

Always check your power amplifier's specifications and settings to find out what the true voltage gain is.

Reducing* limiter thresholds to cater for clipped signals

The **initial** limiter settings shown above provide overdrive protection for your Resolution 4 series loudspeakers for normal, unclipped music and speech use. However, clipped signals can dump up to twice as much power into your system.

Although Resolution 4 series loudspeakers are 3-way active systems and less prone to damage than a full-range passive system would be, it is worth reducing the initial limiter thresholds by 3dB (e.g. +1dB instead of +4dB etc) to prevent premature ageing of components (particularly HF drivers) when renting out your system for an amateur DJ competition, for a particularly animated preacher or for a particularly raucous comedian, for instance.

*** Limiter thresholds may be reduced below the initial settings - to cater for clipped source material or for good spectral balance - but they must never be increased as this would defeat the system protection and could result in prematurely aged or permanently damaged drivers.**

For more about clipping, see **Appendix A** towards the end of this user guide.

7.7 Final limiter adjustments for spectral balance

Another reason for reducing limiter thresholds is to maintain spectral balance when the system is being driven into limit.

Mid and high frequency drivers tend to have lighter, more delicate voice coils and smaller magnetic assemblies than lower frequency elements, heat up much faster and, therefore, have lower power ratings.

However, these lower power ratings with increasing frequency don't usually restrict the mid and high frequency output spl because:

- 1) Mid and high frequency horns can be designed for very high efficiency and
- 2) Natural music and speech signals tend to have quite a "pink" rms spectrum - i.e. signal levels tend to reduce slightly with increasing frequency

Not all amplified material is "natural" - we're a creative species. Most club-goers love sound systems with lots of that classic Funktion One bass impact and this means that, as levels rise (and despite the mids and highs having lower power ratings), the bass system is often the first to go into limit leaving the mids and highs to carry on increasing in level.

It is often, therefore, a good idea to reduce the limiter thresholds of some sections (most likely the mids and highs) slightly to maintain the required spectral balance right into limit and to protect your audience from discomfort.

The procedure is explained by John Newsham on our web site as follows:

Balanced sound "On the limit"

Here are some common scenarios:

- a) *You've got your mix set up and "in the pocket" then the singer gets a bit excited and shouts "Hello (insert your town here)! Are we all having a good time??!" His vocal compressor is set at a low ratio (or there isn't one) and you're not quick enough on the fader to catch the sudden burst of level. Happily your system limiters are set a couple of dB before the clip point of the amps in accordance with the power handling of the drivers and the amps don't clip.*
- b) *A sudden burst of feedback from a vocal mic too near a side fill and the same thing happens.*
- c) *An inexperienced guest engineer loses control of the mix and ends up running too loud, the limiters start flashing and we ask him to back off a bit, he's surprised that it actually starts to sound louder when the masters are pulled down a little and the limiters stop pumping (how many times have I seen this).*

In all these cases the limiters are set for system safety and nothing gets broken, all good but what does the system actually sound like and how loud is it when the limiters come into play?

Mid and HF horns are usually more efficient than low mid and bass drivers. Of course they handle less power but you can often get a situation where if everything is just set for safety the system is capable of being driven into a state of imbalance where it sounds bad and can even be way too loud for the venue and the safety of the people in it.

Bass speakers these days can handle a massive amount of power (as long as it's clean) so large amps are used and limiters set to stop clip from occurring.

Mid and high limiters are set progressively tighter in respect to the drivers lesser power handling.

It's still a good idea to use a large amp though. Transient spikes, totally valid to the music like the hit of the snare or cymbal crashes can get past the limiters and this is good because the dynamics and excitement of the music are preserved and these transients are not long enough to overpower the driver as long as they're not clipping.

So what happens as the system comes up to full power?

- 1) Often the bass will limit first, then as the system is driven harder the low-mid starts to limit, the high-mids are still going strong as are the highs.*
- 2) If the bass limits 4 dB before the mid-highs this is effectively the same as turning up the mid-highs by 4dB. The balance of the system is completely wrong and all the hard work of tuning and sound check is wasted.*

The thing to do here is to reduce the limiter threshold settings still further so that the mids and highs start to limit at around the same point as the bass. This way the frequency content of the music will be maintained when the system is being pushed into limit and the mids will stay at a level where they still relate to the low end.

The settings for this will be different for live and club systems. You will still, of course, want to leave a bit more headroom for the dynamics of live music and in a night club there may be noise restrictions or the owner may have an idea of how loud he wants the system to go.

The principle is the same. In both cases run the system up to the required maximum level, reduce the limiters so that the limit lights are flashing then open up a dB or so to account for when the room is warm and full of people, come back later when the venue is running and fine tune if needed. Above all, lock the system to safeguard against tampering!

Your system will now not only be safe against damage, but will also be safe against being driven out of balance and sounding really bad.

Appendix A - Clipping



Caution

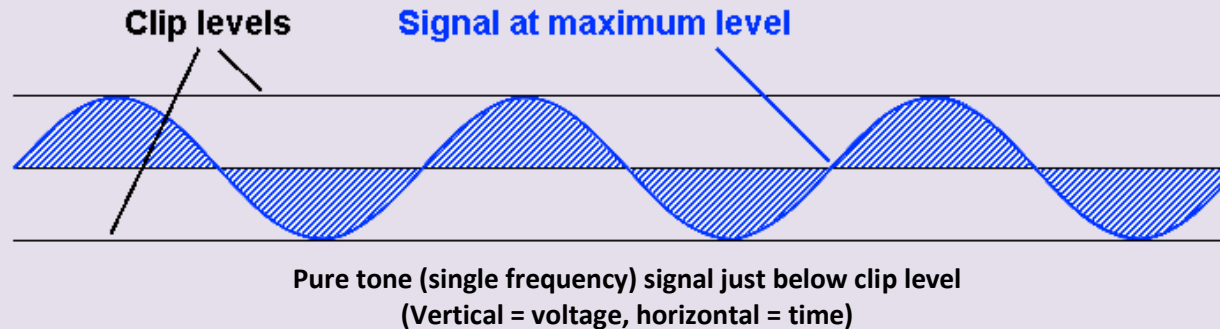
Prolonged heavy clipping can subject loudspeaker voice coils and passive crossover components to double their rated power dissipation leading to overheating, premature ageing or early failure. The high frequency components are particularly vulnerable in systems with passive crossovers.

In extreme cases this could pose a fire hazard.

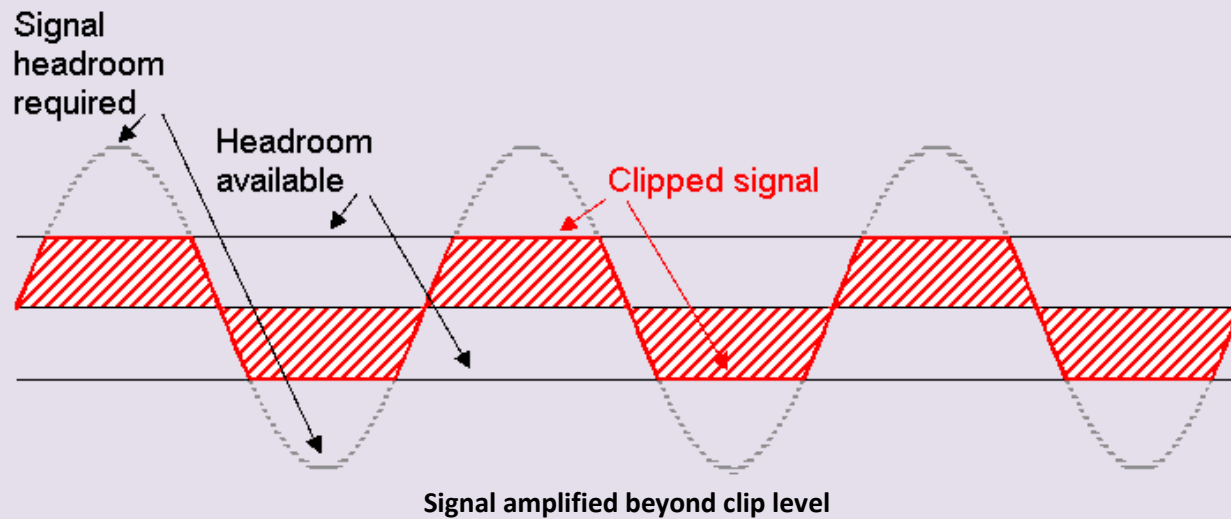
What is clipping and why is it a problem?

When an audio signal is amplified beyond the voltage or maximum digit capabilities of the equipment in use, the peaks of the waveform can get flattened. This is referred to as clipping and is heard as distortion.

Here's a normal signal at maximum level – just below clipping and still within the available “headroom”...
(The clip level sets the maximum available headroom)

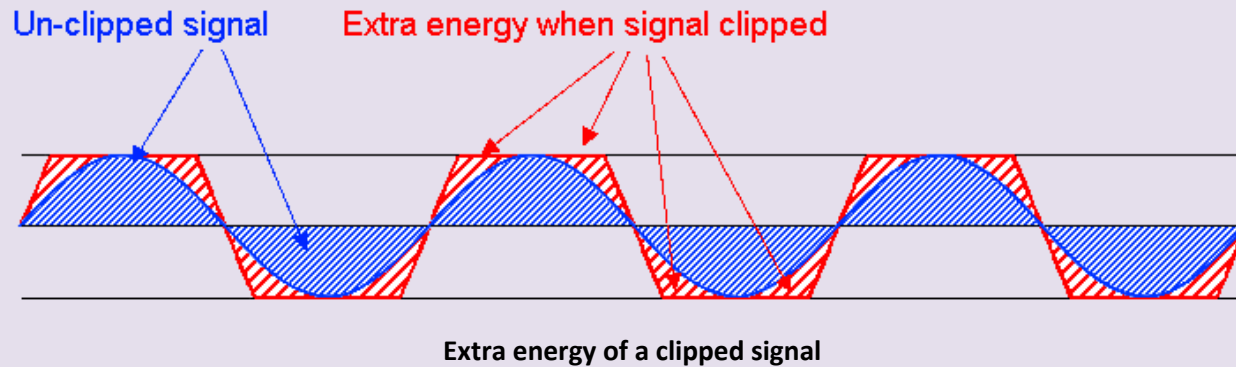


The blue positive and negative shaded areas represent the power the signal would cause to be dissipated in a load – usually a loudspeaker voice coil.
Here's the same signal amplified beyond the available “headroom” – i.e. beyond the clip level...



When a signal is clipped, its waveform squares off.

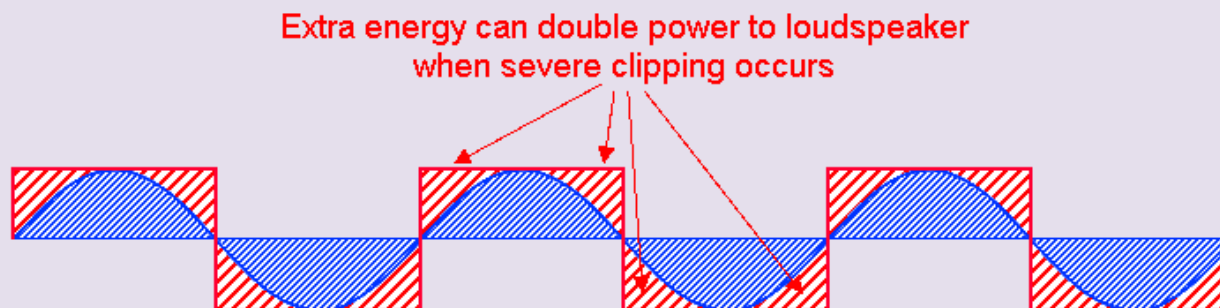
The cross-hatched areas cover a significantly larger area because the signal stays at the maximum positive and negative values for more each cycle. This is easier to see if we overlay the normal and clipped waveform illustrations. The clipped signal's extra content can be seen as the extra red shaded areas.



In extreme cases, the waveform is so heavily clipped that it can resemble a square wave. This increases the rms voltage delivered to the loudspeaker to $\sqrt{2}$ (approx 1.4142) times what would be expected.

The power delivered to the loudspeaker is dependent on the rms voltage².

$\sqrt{2} \times \sqrt{2} = 2$ so the power delivered to your loudspeakers is doubled!



Note that, in all cases, the two waveforms have similar peak voltage levels so this extra energy doesn't always show up on digital audio systems where meters are usually calibrated with respect to maximum digital level (full scale). This is usually written as dBFS.

Digital level meters don't usually take the shape of the waveform (and its potential voice coil heating effect!) into account - hence the warning at the beginning of this Appendix.

To avoid overheating loudspeaker voice coils – particularly HF voice coils in passive loudspeaker systems – try not to clip signals repeatedly or for long periods.

Clipping and its effect on frequency content

All waveforms are made up of combinations of fundamental frequencies (main tones) and harmonics (multiples of the fundamental frequencies, also known as overtones) in a variety of amplitude and phase relationships.

Spectrum analysers can be used to show this. In the screen shot below, an unclipped pure tone (approximately 1kHz) can be seen as a single frequency line.

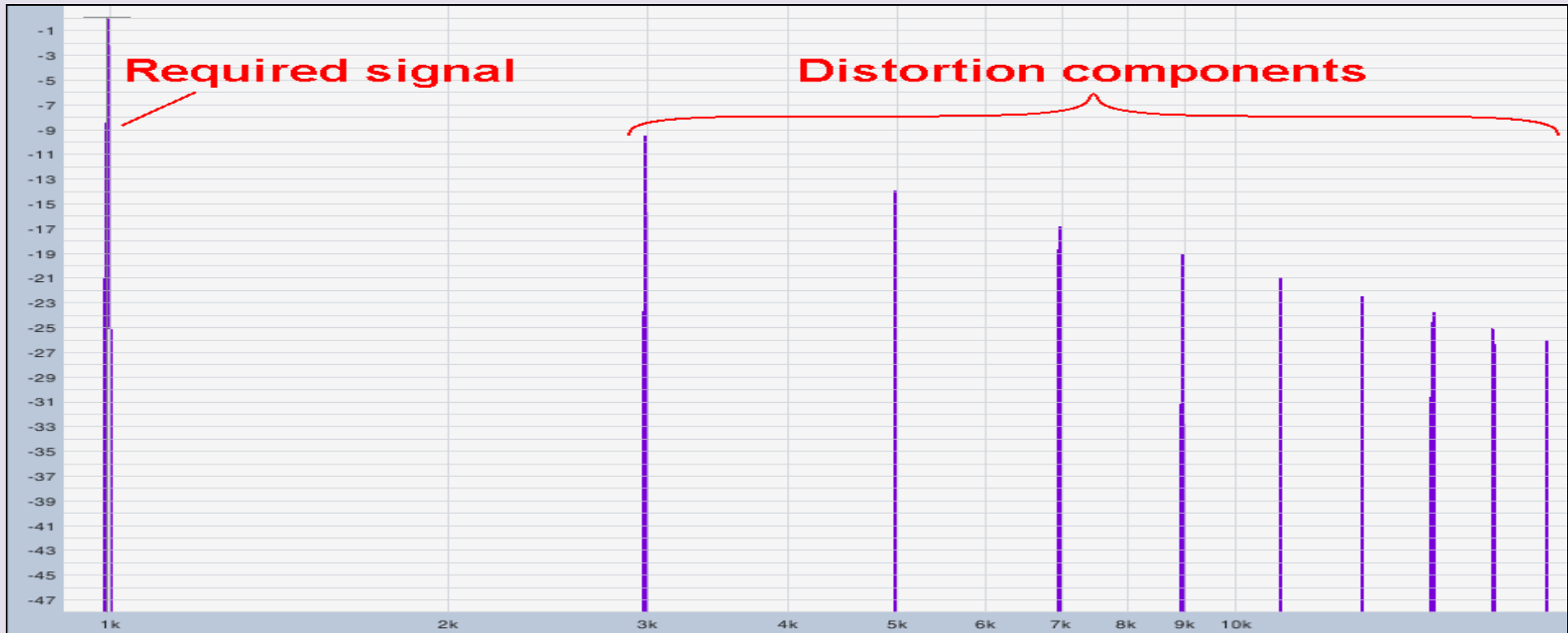


**1kHz pure tone just below clip level
(Vertical = level in decibels, horizontal = frequency)**

The spectrum (above) is that of an undistorted pure tone. Note the single, pure, frequency point.

Now see what happens when you clip a signal...

The heavily clipped signal on the next page shows clipping distortion as a series of odd harmonics at 3kHz, 5kHz, 7kHz etc., whose levels decrease with frequency at approximately 6dB per octave. Where clipping occurs before the system crossover, clipping harmonics can crossover into the HF driver and the HF driver can be called upon to dissipate far more power than normal.



1kHz heavily clipped signal

Note that the example shows a single frequency fundamental. Musical signals will be a lot more complex and the distortion content will be denser. Asymmetrical clipping (from studio or backline valve amplifiers, for instance) would also include even harmonics.

As mentioned earlier, long-term clipping can be avoided – and performance improved - if you choose mixers, effects units, controllers and amplifiers with adequate headroom and set your limiter thresholds to below clipping levels. You can also avoid clipping your signals at source by setting your console and effects system “gain structure” carefully. See [appendix B...](#)

Appendix B – Gain structure

What is gain structure all about and why is it important?

When an audio signal passes through an analogue or digital audio system, it is important to maintain the optimum signal operating level through the various sections of the signal path. Microphone levels must be boosted to make them compatible with line level and analogue-to-digital converter stages and mix stages must allow enough headroom for multi-channel summation.

The various gain settings throughout a piece of audio equipment are collectively known the system's gain structure.

Signal level too low

If the signal level is too low it will be wallowing around in the analogue noise floor losing resolution and becoming fuzzy, distorted and noisy in the digital domain.

Avoiding digital garbage

If you have to go digital for your multi-channel live sound operations, use 24-bit systems - if they are available - so that you can maintain enough headroom to mix without sinking into the digital mush. And, of course, if you like to use lots of effects, try to use one, comprehensive, studio-quality effects system that runs its internal processing at 32-bit floating point. This reduces the build-up of mush you get every time your signal goes through a different processor.

Signal level too high

If your operating levels are too high, there won't be enough headroom to allow for performance peaks and multi-channel mixing. You may end up with distortion caused by peak clipping - or even long-term clipping.

If you're using all-analogue equipment, the odd peak clip may go unnoticed as long as it's not sustained enough to damage your HF drivers. This is because analogue clipping components are harmonically related to the original signal.

Avoiding digital mush

Unfortunately, digital overload isn't as simple. You get clipping when the digital stage runs out of digits – usually referred to as 0dBFS – and the higher order harmonics generated can then alias with clock frequencies creating all sorts of strange sum and difference frequencies. These aliasing products can be interesting if you're a robot but are generally heard by humanoids as nasty and unmusical. They can also turn cymbal "tings" into "shhhs" and make vocals excessively sibilant.

To make matters worse, any over-sampling or delay-based processes built into effects units, can stretch these nasty artefacts in the time domain and make them far more audible than their relatively low levels would suggest. Also remember that aliasing will be compounded as the overloaded signal passes through successive processes.

Signal level just right

If your operating signal levels are just right, you won't run out of headroom, clip or run out of digits – even on musical peaks. And you'll still run well above the analogue noise floor and stay clear of the digital mush.

So what is “just right”?

It all depends on the type of audio material and your application.

Live sound mixing

If you're going to be mixing audio from a variety of live musical instruments or you're going to be creating some broadband effects over a wide dynamic range, you'll need to allow plenty of operating headroom to avoid analogue clipping or, worse still, running out of digits.

DJ mixing with pre-recorded material

If you were only ever going to work with pre-recorded, auto-levelled material, you'll probably get away with just enough headroom to mix tracks and add the odd effect – but read the whole section anyway, you may find it instructive.

Live sound operating levels

It is important to retain enough headroom to maintain good transient response, details and impact for live sound mixing – not only to allow for backline systems being turned up to “11” mid-set and for high peak-to-rms percussion transients, but also to allow for the natural signal level build-up through the console, once you start tweaking eqs, adding effects and sub-grouping multiple channels.

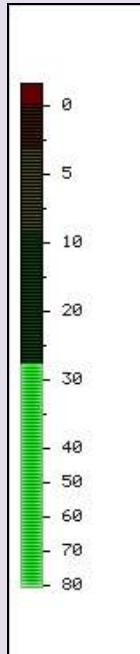
*Assuming a professional quality analogue or 24-bit digital console, run each channel's pre-fader or level and each group's mix level at around **0dBu/+4dBu (analogue)** or **-18dBFS (digital)** if at all possible.*

Modern 24-bit systems with good studio quality converters usually work well at -18dBFS but some MI products may use lower grade converters which will need to be run at higher operating levels to avoid sounding mushy. If you suspect this is the case with your system, you'll need to run the PFL or group levels around the -12 to -9dBFS level and keep an eagle-eye open for signal clipping during the live performance.

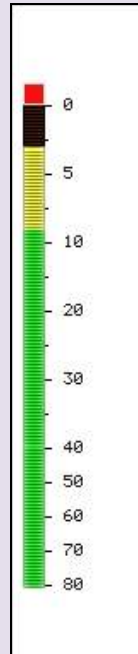
Understanding level meters

This section spends a lot of time discussing meters because, without an understanding of their typical calibration levels, it's difficult to get your gain structure and operating levels properly optimised.

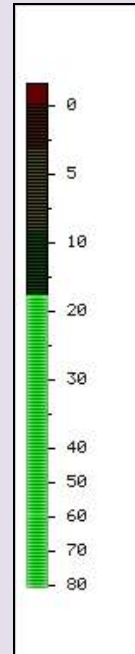
Professional live sound meters calibrated with respect to "Full Scale" (dBFS)



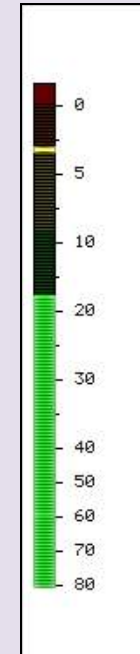
Too low (-28dBFS)
Wasting dynamic range



Too high (-3dBFS)
Peaks could be clipped



Just right (-18dBFS)
Noise-free without clipping



Peak-hold option
May not be true peak

The illustrations above show levels on a typical bar meter with a dedicated peak LED at the top. Some analogue peak LEDs don't respond to very fast transients and some digital ones don't respond until the processor has seen several maximum bits in a row. Peak-hold indicators often hold maximum rms – not true waveform peaks – so they are not always a good indicator of potential clipping.

If, for live sound, your bar meter is way above the -18dB mark, you're probably clipping peaks and transients irrespective of what the peak LED or peak-hold indicator is telling you.

Q & A

Q) Surely 18dB below clipping (-18dBFS) won't drive my loudspeaker system hard enough?

A) Remember that 18dB below clipping represents about +4dBu/0VU output level on most pro-audio consoles.

Effects, eq., mixing and natural performance dynamics will require the 18dB of headroom through your channel, effects and subgroup sections.

Lower-cost digital console calibration and limited converter quality may push you towards an operating level only 12 to 9dB (-12 to -9dBFS) below clipping as mentioned earlier. -9dBFS is an old DIN standard but it's the exception rather than the rule – particularly with modern 24-bit systems.

Once you've done all this without crashing the mix, you can then use the **master faders** to push the required level to your main system amplifier racks where your controller limiters will take care of the odd rogue peak.

Standard EBU alignment level for digital audio is also 18dB below full scale (maximum digital level) - usually written as -18dBFS - so sticking to the 18dB rule will also make you compatible with broadcasters when working at festivals and VIP DJ events.

Professional live sound analogue meters calibrated with respect to +4dBu

Most pro-audio analogue equipment can handle internal and output signal levels of approximately 10vrms before clipping. 10vrms is approximately +22dBu so 18dB below that clip levels is approximately +4dBu.

Traditionally, most pro-audio VU-meters (and VU-scaled bar meters) were calibrated so that 0VU corresponded to the industry standard +4dBu to give you 18dB of headroom.



Too low (-10VU = 28dB below clip)
Wasting dynamic range



Too high
Peaks could be heavily clipped



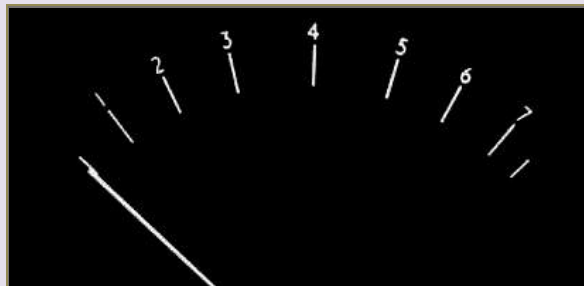
Just right (0VU = 18dB below clip)
Noise-free without clipping

More Qs & As

- Q) What's a dBu?
- A) dBu (sometimes written as dBv) refers to so many dB with respect to approximately 0.775vrms. You've probably seen the 0.775vrms standard used for power amplifier sensitivity.
- Q) Why the strange voltage reference?
- A) The original standard was devised for telephone circuitry and early audio. It was originally called dBm and was defined as 1mW into 600 ohms. Work out $0.775^2/600$ and you'll get a milliwatt.

Professional analogue and digital peak programme meters (PPMs)

Peak programme meters don't actually measure short signal bursts or transients. They are designed for estimating programme levels.



UK "BBC" PPM scale – in 4dB steps
"4" is usually set for -18dBFS



EBU PPM scale – also in 4dB steps
"Test" is usually set for -18dBFS

There are almost as many PPM scales as there are broadcasting authorities – including a "DIN" standard - where "0" is only -9dBFS!

PPMs move faster than most rms meters in response to tone-bursts and fall back more slowly – making them easier to read. But they still underestimate very short bursts and often ignore transients altogether so the 18dB below clip rule must still apply.

K-meters

K-meters – named after Bob Katz, the well-known mastering engineer – usually measure rms levels with a fixed 600ms integration and fall-back time over a very wide level range.

Some versions include peak facilities. K-meters usually have switchable scaling: K-20 indicates 0dB at -20dBFS, K-14 has 0dB at -14dBFS and K-12 has 0dB at -12dBFS.

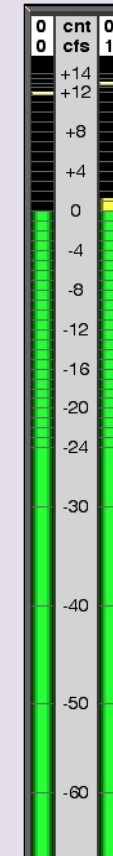
As most K-meters are software-based, it is possible to select K-20, K-14 etc as required. Live sound users should use the K-20 standard wherever possible.

K-meters were designed for recording applications – and as an attempt to get some consistency in control room monitoring levels. For recording purposes, 0dB is set for 83dBspl but this isn't relevant for live sound use.

A K-meter's main advantage in live sound applications is its accurate indication of levels with reference to full scale.



**Sondris Meter
(Set to K-20)**



**Spectrafoo meter
(Set to K-14)**

Gain structure basics for live sound console users

- 1: *Ensure that all inserts, gates, compressors or plug-ins are bypassed before initially setting your gain structure! See **Outboards effects set-up** later...*
- 2: *Adjust your input channel mic/line gains for PFL (pre-fade listen) levels around +4dBu/0VU (analogue), -18dBFS (digital) or the top green indicator (DJ)*

You may need to trim input gains if the input levels change dramatically during the set. Remember that musicians tend to play louder with an excitable audience in place so allow at least 6dB of spare gain control

If your signals are too hot, even with the gain control below the 9 o'clock position, use a less sensitive input, perhaps line instead of mic, or the console pad switch

If your mic signals are too weak, even with the gain control above the 3 o'clock position, recheck your patch and make sure any input pad or insert points are switched out. It's also worth checking your mic specifications –in case the mic needs phantom power
- 3: *Once you have a healthy PFL level, adjust the relevant subgroup or fader for AFL (after-fade listen) levels around +4dBu/0VU (analogue), or -18dBFS (digital) with the channel routed and faded up to the nominal 0dB fader mark*

Note that, for professional analogue consoles, this assumes that the nominal 0dB fader mark is 10dB below full fader level and that there is gain make-up between the sub-group fader output and the AFL point. Non-professional consoles may not have this gain make-up so you may need to run at lower AFL levels (around -6dBu) to maintain pre- subgroup fader headroom
- 4: *Channel faders will eventually be set to the levels required for artistic balance. Large numbers of channels routed to the same subgroup or output will raise overall mix bus levels and you may have to drop channel fader levels by 2-3dB every time you double the number of channels routed to the same mix bus to maintain headroom*
- 5: *Adjust your master/output faders for the required sound level*
- 6: *Readjust channel gain controls for suitable pfl levels if specific input levels change, or after tweaking any channel strip effects or eqs*

Note that short-term transients and peaks in live music - plus mix summing - can easily use up your headroom. Don't be tempted to drive channel rms levels much beyond +4dBu/0VU/-18dBFS if you want to minimise peak clipping and signal degradation further down the signal path.

Again, remember that you can always push the system harder using the master fader, once you've developed a clean mix.

Outboard effects set-up

*Assuming you have set the relevant console channel with everything bypassed as above, switch in your inserts. **If the outboard gear isn't too noisy or mushy, use the 18dB-below-clip rule.***

Outboard gain structure

- 1: With your outboard equipment's input gain set to a nominal level (about 1 o'clock if it's an analogue knob), set the relevant insert send control on your console so that your outboard gear's general level is indicating around 18dB below its own maximum (usually -18dBFS on digital gear).*
- 2: With your outboard equipment's output control set to nominal, set the relevant insert return control on your console for PFLs around +4dBu/0VU (analogue) or -18dBFS (digital).*
- 3: Listen to the required effect – on headphones first and then on the PA.*

If the outboard gear is too noisy or has poor quality converters, you may have to compromise on headroom by increasing the insert send level by a few dB and decreasing the insert return level by the same amount.

If the outboard gear is starting to sound distorted at your likely maximum effect, you may need to bring its internal signal level down by reducing your console insert send level and increasing the insert return sensitivity by the same amount.

Appendix C - “Maximum spl” specifications

Funktion One publishes a calculated “maximum spl figure” for guidance only. Potential purchasers should be aware, however, that neither calculated nor measured maximum spl figures are a reliable figure of merit or comparison as there are no hard and fast rules when it comes to assessing maximum sound pressure level.

Manufacturers tend to pick ‘n’ mix the parameters that make their product look best. Some calculate maximum spl, but ignore factors that might detract from that all-important magic number. Others measure responses but choose to ignore vital musical parameters such as power-bandwidth and distortion. Some only quote peak spl using ridiculously short test durations that bear little relationship to musical performance criteria.

And don’t be fooled into thinking that manufacturers with impressive “educational” programmes publish more relevant figures. Sadly, the small print would suggest otherwise.

In short, it’s a marketing jungle out there and the buyer should beware.

Introduction

Maximum spl figures are often thought of as a key parameter when assessing the suitability of a loudspeaker system. They are the starting point for sound designers’ spl versus distance predictions when working out which loudspeaker system will provide the required performance for a particular installation or event.

But are manufacturers’ maximum spl figures reliable – or, indeed, comparable?

Manufacturers’ small print suggests that a wide variety of calculation and measurement methods are in use. This makes it impossible to compare different manufacturers’ data directly.

Most manufacturers quote **calculated** maximum spl figures based on their product’s sensitivity and their driver supplier’s power ratings. Calculations are easier to do than actual measurements and most manufacturers are honest enough to admit this, stating a lack of suitably isolated locations or facilities. One manufacturer, however, has been known to imply that mics aren’t available to measure beyond 140dB. They’ve obviously never heard of **Brüel & Kjær**.

Manufacturers who calculate maximum spl figures don’t usually indicate the applicable bandwidth or the likely distortion levels. See the **Calculation** notes below.

Manufacturers who measure maximum spl figures quote a variety of test signals, endurance time and boundary conditions – or none at all. As **each** measurement criterion can affect the resultant maximum spl figure by between 3 and 6dB, it is virtually impossible to compare different manufacturers’ spl specifications once all possible criteria are taken into account. See the **Measurement** notes further down.

Calculation

You'd be forgiven for thinking that maximum spl ought to be fairly easy to calculate. After all, we know how to measure loudspeaker sensitivity. We simply apply one watt of signal and see what spl we measure at one metre on axis. And loudspeakers' maximum power ratings have been standardised since the Audio Engineering Society (AES) published the original recommendations, AES2-1984, several decades ago. This was revised in 2003 and is still commonly used.

All we have to do is work out the AES power rating in dB, with reference to one watt, and then add that figure to the sensitivity figure, surely?

Working out the AES power rating in dB, with reference to one watt, and then adding that figure to the sensitivity figure is, indeed, a common way of calculating maximum spl so most manufacturers have little choice but to follow suit. This industry tradition appears to allow potential purchasers to compare and contrast different products from different manufacturers. But, unfortunately, the figures can cause unfair and misleading comparisons making the whole exercise pointless.

Here are some points to consider:

Sensitivity

1. Loudspeakers rarely have ruler flat spl versus frequency characteristics. Some manufacturers take advantage of this and quote the loudspeaker's sensitivity for a single octave centred on the highest peak, rather than quote an average sensitivity for the loudspeakers' full frequency range. This means that a loudspeaker with a really nasty mid frequency resonance in its response could look better in terms of both sensitivity and maximum spl.
2. Quoted frequency ranges are not always the ± 3 dB you might expect. They're often defined as the upper and lower frequencies where the loudspeaker's spl drops 10dB lower than the average level of the most sensitive octave (see below). So, instead of ± 3 dB, they're +0dB, -10dB with respect to an octave averaged response peak. This means that a system's sensitivity may be 10dB lower at the upper and lower ends of its frequency range.
3. Loudspeakers don't usually have flat impedance versus frequency characteristics either. Typical direct radiator loudspeaker impedances tend to peak at the main system resonance, drop back a little, and then rise at high frequencies due to the voice coil inductance. They are also designed to be **voltage** driven rather than power driven.

And most power amplifiers are designed to deliver a flat voltage versus frequency characteristic. So it would be more realistic to quote a loudspeaker's sensitivity in terms of dB spl (on axis at one metre) versus drive voltage.

Some manufacturers already do this, working out the nominal voltage required to deliver one watt at their quoted nominal impedance. But sensitivity is still rarely quoted versus frequency so points 1 and 2 still prevail.

AES power rating

1. A loudspeaker driver's AES power rating is its long-term (typically, two hours) **free air** power rating. Many loudspeaker manufacturers simply reiterate their driver supplier's figures which may not allow for the effects of voice coil heating (compression) under real-world loading conditions. This is particularly relevant to inefficient, heavily processed loudspeakers whose manufacturers like to get into the race for ever more unrealistic power

handling claims.

Funktion One tries to avoid this kind of power war, by concentrating on turning the electrical signal into sound through highly efficient loudspeaker system designs.

2. AES2-1984 (r2003) states “The rated power of the device shall be that power the device can withstand for two hours without **permanent** change in acoustical, mechanical, or electrical characteristics, greater than 10%”. This means that a loudspeaker’s AES power rating only refers to its resistance to permanent change (or failure), not to its linear operating range. It is quite permissible for a loudspeaker to generate excruciating levels of distortion or to suffer from several dB of output compression as long as a **permanent** change doesn’t take place.

AES2-1984 (r2003) recommendations mention distortion measurements being made at 10% of the AES power rating. This is perfectly reasonable for highly efficient loudspeakers, such as Funktion One systems, as most musical levels will be sitting well below the loudspeaker’s AES rating. But inefficient, power hungry systems are likely to be running much closer to their AES ratings producing unacceptable levels of distortion and mush.

Current measurements of peak displacement limit maximum driver excursion (X_{max}) to 10% deviation from linear displacement but manufacturers can get around this by choosing their test bandwidths carefully. The recommendations allow manufacturers to choose between quoting input current distortion or percentage deviation of displacement. The two types of distortion are not the same (and don’t necessarily increase linearly with excursion) so manufacturers could simply choose whichever result looks better in the calculations. Unfortunately, distortion is rarely quoted so all this work could be wasted anyway.

There is now a proposal to measure X_{max} at 10% total harmonic pressure distortion or at 10% 2nd or 3rd order modulation distortion using a two-tone signal where the upper frequency component is 8.5 x the frequency and at a 12dB lower level than the lower frequency component.

3. AES2-1984 (r2003) recommends that the test signal is band-limited pink noise and states that “The manufacturer shall state the upper and lower cut-off frequencies (-3dB) of the noise signal”. Most loudspeaker system manufacturers simply say “band-limited pink noise” without quoting upper and lower cut-off frequencies so it’s impossible to know if low frequency excursion is going to be a limiting factor in practice.
4. AES2-1984 (r2003) also recommends that the test noise has a 2:1 peak-to-rms voltage ratio – i.e. a 4:1 peak-to-average power ratio. This leads some manufacturers to quote peak power ratings of four times the long-term AES rating. This is quite permissible as long as the peak power figure is only used to supplement the normal AES power rating – and, of course, the peak power rating doesn’t cause over-excursion at very low frequencies. Again, some indication of upper and lower frequency cut-offs would be helpful.
5. Some manufacturers also add a nominal 6dB spl to their calculated maximum spl figure to allow for “half space” or “ 2π ” (hemispherical) floor or wall loading. This can make sense at low frequencies, where small loudspeakers exhibit omnidirectional pressure characteristics. It also makes sense for subwoofers whose response extends low enough for the listener to be regarded as existing in half-space. It doesn’t make sense, however, for directional horn sections whose coverage doesn’t wrap round to the boundary. Again, an indication of bandwidth would help here.

To summarise calculated maximum spl problems:

- The quoted sensitivity – which is, after all, the basis of most calculated maximum spl figures - may be optimistic by up to 10dB at the upper and lower ends of the frequency range.
- Likely distortion figures are rarely mentioned.
- Most manufacturers' calculations ignore long-term voice coil heating and the resultant compression.
- Manufacturers who state **peak** spl may have added 6dB to figures calculated using their driver suppliers AES power ratings.
- Manufacturers who state “half space” or “2 π ” conditions may have added a further 6dB to their figures.

Measurements

As mentioned earlier, manufacturers quote a variety of test signals, measurement parameters, endurance times and boundary conditions:

1. As far as test signals are concerned, some manufacturers quote “IEC 60268 noise” that has bandwidth and peak-to-rms characteristics similar to the AES recommendations for power ratings (see earlier).

Some simply state “band-limited noise” without specifying upper and lower frequency limits – whilst others don't specify their test signal at all.

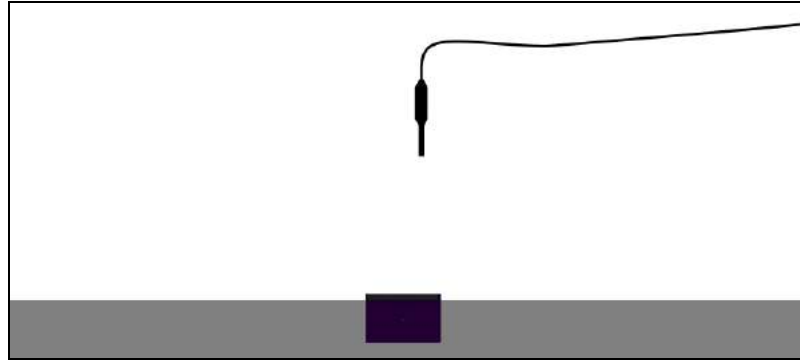
The choice of test signal makes quite a difference. For instance, the rms level difference between sine sweeps and AES or IEC noise can be 3dB. And regular (non AES or IEC) pink noise differences can be considerably greater.

The combined choice of measurement parameter and test signal can make quite a difference as well. A peak spl reading will look a lot more impressive than an rms reading – especially with regular pink noise instead of AES or IEC noise. The pink noise's peak measurement will be at a maximum but its unmentioned rms value – and, therefore, its tendency to heat the voice coil and cause output compression – is likely to be considerably lower than the AES or IEC recommendations.

2. Also, the careful choice of spot frequencies or noise bands can exaggerate the maximum spl figures to unrepresentative levels.
3. Most manufacturers agree that loudspeaker systems needs to be run for at least two hours for their magnetic assemblies and chassis to reach maximum operating temperature. However, very few manufacturers state measurement duration. One manufacturer quotes maximum spl figures based on peak readings of pink noise and further reading reveals that their product's “peak power handling capacity” is quoted for 10ms. That's only one cycle at 100Hz! Try explaining that to a bass or keyboard player who likes to play sustained notes!
4. Manufacturers who mention boundary conditions tend to state “half space” or “2 π ” (hemispherical) conditions. Again, this can make sense for small loudspeakers at low frequencies. And, of course, for subwoofers whose response extends low enough for the listener to be regarded as existing in half-space.

5. Note that there are two types of “half-space” set-up used to minimise the effects of delayed ground reflections where an anechoic chamber isn’t available:

- i) The most common set-up is where the loudspeaker is mounted in half space – typically in a pit facing upwards so that its baffle (not its grille) is flush with the ground. The measurement microphone is placed above the loudspeaker – usually on the acoustical crossover axis.



This half space loudspeaker set-up will show a level enhancement of up to 6dB at very low frequencies where the loudspeaker response is almost omnidirectional. Results correlate nicely with the real-world listening experience.

- ii) The second set-up is where the loudspeaker is placed on or near the ground and its acoustical crossover axis is tilted towards a “boundary” microphone. The microphone is a small, but accurate, omnidirectional measurement microphone with its capsule facing the direction of the loudspeaker – but placed snugly against the ground. This half space microphone set-up will show a level enhancement of up to 6dB over the full frequency range of the loudspeaker being tested, as long as the surface is hard and smooth.



The method can be problematic, though, depending on the loudspeaker’s off-axis polar response and ground irregularities at high frequencies.

The boundary method also tends to enhance the mids and highs when compared with real-world listening conditions - where most listeners' ears tend to be several wavelengths above the floor at mid and high frequencies. The pit method (i) is preferred.

6. There are still some manufacturers who state “open space” or “4π” (spherical) conditions. It’s a difficult condition to meet in practice as you need a measurement chamber that is anechoic down to the lowest frequency to be measured. Unless, of course, you hoist the loudspeaker and measurement microphone high above the ground...

To summarise measured maximum spl problems:

- There is usually no way of knowing what test bandwidth a manufacturer has used as this is rarely stated. Maximum spl measured at a response peak is useful for alarm sounders but meaningless if you’re interested in broadband performance.
- Different manufacturers use different test signals and these can have significant effects on, for instance, peak measurements, as accompanying rms levels will be different. Remember that pre-recorded contemporary music can be more compressed than classical recordings – so peak-to-rms factors may be relevant to your installation.
- Some manufacturers don’t allow adequate warm-up time or measurement duration so maximum spl figures don’t include long-term compression. Maximum peak or burst spl figures are useful – but they should only be used to supplement the normal AES power rating and not to replace it.
- Manufacturers rarely define the test conditions adequately. Not all “half space” set-ups are equal. Half space loudspeaker measurements can make perfect sense but half space microphone measurements may yield mid-high figures that are up to 6dB higher than is achievable at ear-height.
- Again, distortion figures are rarely mentioned. Efficient designs tend to generate less distortion than inefficient ones for the same spl. Beware products with impressive maximum spl and AES power rating figures but no mention of distortion. Power hungry and loudspeakers doesn’t necessarily equate with musicality and projection.

Powered loudspeakers

Maximum spl figures are often quoted for powered loudspeakers but very few manufacturers quote figures as per the drivers’ AES power ratings.

Before miniature power modules were available, amplifier recommendations were based on the driver’s AES power rating. This was tested using noise with a 6dB peak-to-rms voltage ratio. This implied that a good power amplifier would be capable of supplying the driver’s AES power continuously and that it would be able to supply four times that power in bursts.

Amplifiers built into loudspeakers tend to be quite small for aesthetic and weight reasons and are often based on designs with large enough voltage swings for instantaneous peaks, but inadequate power supply capacity for sustained performance. It is not unusual for powered loudspeaker manufacturers and power module OEM suppliers to quote maximum power for just a few hundred milliseconds (often less) and to quote peak or burst power for only a few tens of milliseconds. So that impressive maximum spl figure wouldn’t be relevant for sustained bass or keyboard notes.

Such systems tend to sound impressive on opening percussion runs with single or sparse instrumentation, but they rapidly degenerate into a mush once the full band and vocals strike up.

Limiters

Limiters are usually employed to protect the drivers from accidental overload – especially in powered loudspeakers and professional touring systems. But they can also be used to provide a more acceptable spectral balance when the system is being driven hard.

Go to www.funktion-one.com/settings/ for further information.

Most maximum spl figures are calculated from driver sensitivities and AES power ratings so limiters don't really feature in the arithmetic. It would be helpful if manufacturers stated the decrease in maximum spl expected with their recommended limiter settings dialled in. This, of course, should be with AES noise that is band-limited to the pass-band of the relevant loudspeaker or section.

Note that these figures will depend on limiter attack and decay characteristics, and not simply on limiter thresholds.

Again, when measured figures are quoted, it would be helpful if manufacturers quoted the maximum continuous spl and maximum peak or burst spl using the recommended or in-built power amplifier and using the recommended or pre-programmed limiter settings.

Conclusion

Neither calculated nor measured maximum spl figures are a reliable figure of merit or comparison as there are no hard and fast rules when it comes to assessing a loudspeaker's maximum sound pressure level.

Current methods are not transparent enough for potential purchasers to assess different products from a variety of manufacturers and make sensible comparisons.

Many years ago loudspeaker driver manufacturers embraced AES2-1984 to provide consistency between driver manufacturers' power ratings. The professional audio industry has enjoyed an improvement in driver quality and reliability since then because the competitive focus shifted perceptibly from "smoke and mirror" sales techniques to genuine technical improvement.

We now need a similar industry shift towards an agreed standard for testing and reporting complete loudspeaker system specifications. These specifications should include distortion versus frequency – and versus operating levels. The current single-figure maximum spl specification owes more to the alarm industry than to a serious professional sound industry.