DOME SPEAKER ARRAY SUMMARY

1. Introduction

It has been demonstrated that a speaker array can be effectively used to simulate a range of conditions for compact consumer device testing. One common obstacle to experimentation, development and potential commercial application of this established technology is the cost and general availability of consistent and easy to setup speaker arrays. Furthermore, quite often the installation time, required space, reliability and ongoing maintenance of bespoke arrays is prohibitive for wide application. There has not been a readily available turnkey system well suited to setting up consistent testing across multiple sites.

The DickinsAudio arrays were designed from a long-term engineering effort to design an array that could be as easy to source as Ikea furniture, but as accurate as the best spatial sound reproduction labs in any research or industrial lab.

DickinsAudio has developed a practical and innovative approach to speaker array kits that are well suited to this sort of application. In 2019 DickinsAudio was founded with a primary goal of making low cost arrays widely available for students and artists: to make spatial sound simple, fun and accessible. The wider idea is to greatly expand the creative artistic and educational community that can engage with interactive spatial sound, and draw in a new generation of users, applications and innovation.

DickinsAudio offers options for full sphere or dome style self-supporting arrays ranging in size from 1000 to 4000mm diameter. In this document two sizes are shown for a room sized testing facility having 2600mm (8.5') or 3600 outer diameter (12'). These two sizes may suit work for device testing and the use of system such as a HATS or other simulated near field human simulation. These arrays will take around <2 hours for two people to setup.

2. Speaker Count and Geometric Configuration

The geometry proposed for the Array consists of 26 speakers arranged in a truncated rhombic triacontahedron. This shape would extend to a full sphere with 32 channels and it is sometimes known as the 'soccer ball' geometry. The rhombic form is a variant that has different radii for the five point and three point speakers, which maintains a more constant ratio of speaker proximity to angular density. It also has the advantage of a single pole length and the planar rhombic faces provide better force dispersion with the poles being vertical around the median plane. Below are two renders of the array at proposed size.

An array of this geometry can be scaled simply by changing the length of the poles (and cables). Therefore, it is possible to have the same speaker set used at different scales as needed. The key dimension is the pole length, and the approximate relationships following will hold for the outer bounding dimensions:

Outer Diameter = (Pole Length + 66mm) x 3
Height = (Pole Length + 66mm) x 2.4

With the range in size, arrays below 2000mm diameter become very rigid and are able to bear weight and stress of movement easily – a 2000mm array can sustain a 100kg suspended load. At 3000mm the arrays remain rigid and easily moved around in a single piece, however there is flex and moving or load bearing will stress the vertex pieces. Caution is advised. At 4000mm and above, the structure will still support its own weight and therefore simple assembly, however it is suggested these sizes are fixed in place with additional tie off or strapping and not moved as a single piece. For larger arrays a larger edge is suggested for greater strength and sound level.

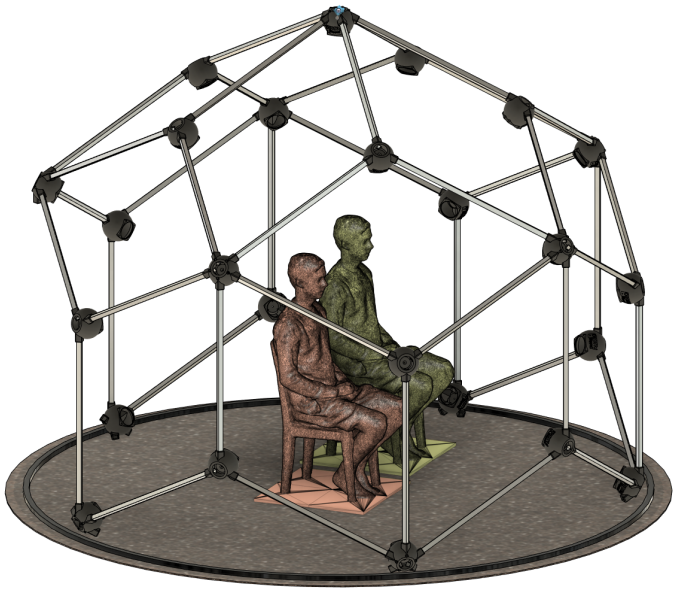


Figure 1 Scale model of 26 speaker truncated rhombic triacontahedra. Black circle shows the outer diameter at 2600mm and the height is 2100mm. Two occupants are shown with scale with 500mm square base and 1100mm ear level. Pole length is 809mm. This size is useful for small intimate public demonstrations, individual subject experiments or a target small room mastering setup. The system is free standing and rigid.

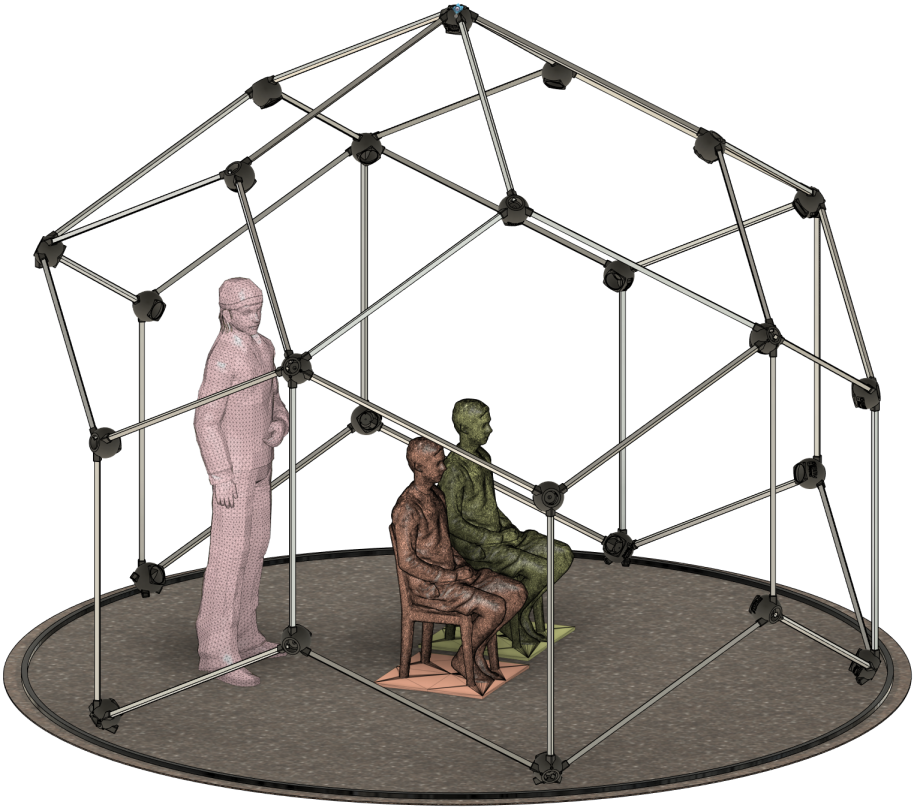


Figure 2 Scale model of 26 speaker array with pole length of 1146mm. Outer diameter is 3600mm and the height is 2900mm. A standing adult is now shown with height 1800mm. With one speaker removed a reasonable entrance is available and shown at the rear. At this scale, the system will have some flex and can be damaged without care. For any public installation, some support or supervision is required.

The effective speaker arrangement has 5 way symmetry and presents 5 offset rings of 5 speakers each, with one speaker at the apex. From the notional acoustic centre of the array, these rings are angles of -26, -13, 13, 26, 53 and 90 degree elevations. As noted, the radial distance is slightly different from the acoustic center with full details generated for the provided sized poles.

Each of the speakers on the ground plane terminates a line of speakers in a serial bus of either 5 or 6 channels. These 5 cables are then brought back through the array poles or around the array to the amplifier or cabling break out for custom amplifiers. A full plan of the speaker geometry when looking from the inside as a Mercator projection is shown in the following figure including the angles of azimuth and elevation.

The construction tolerance is generally +-10mm[1] allowing for some sag and compliance. Ideally the structure should be tied off against a wall or ceiling if being used for extended periods.

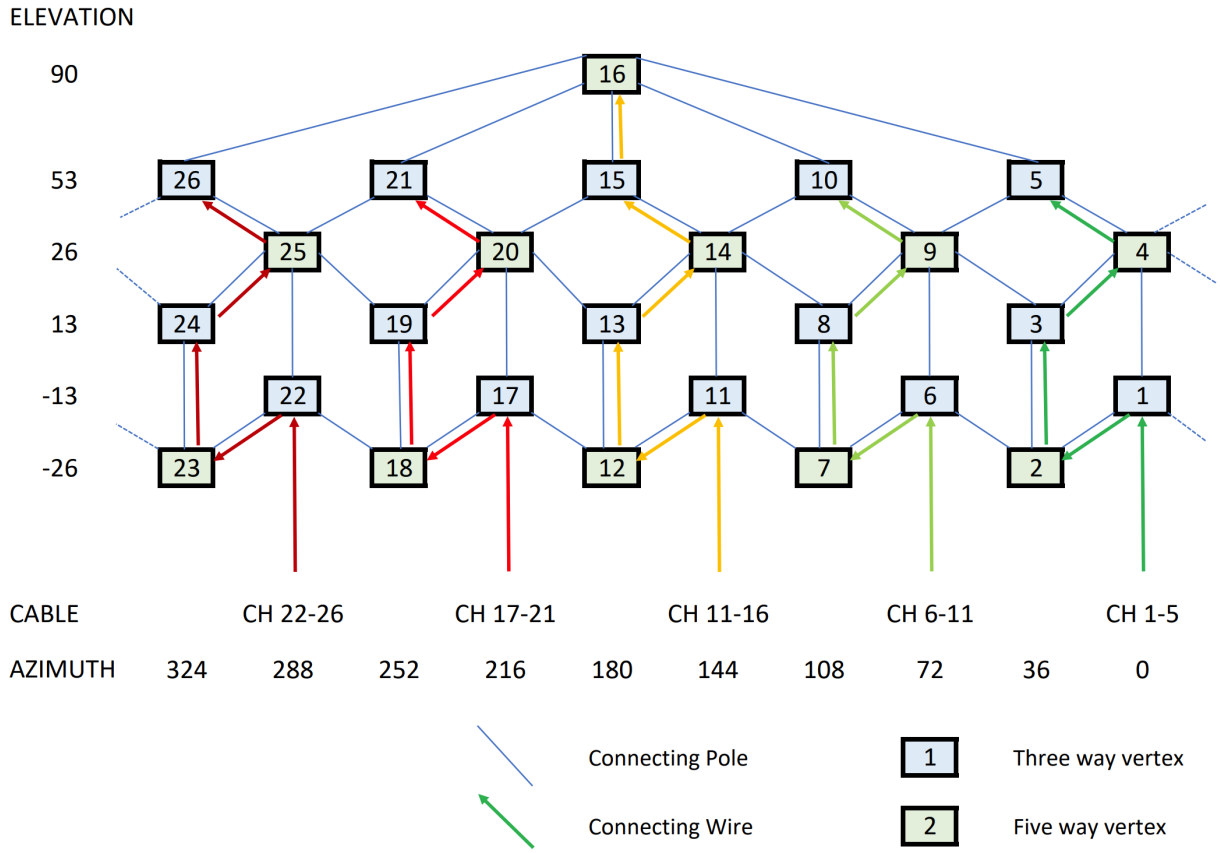


Figure 3 The map of the speaker geometry, numbering and cable runs as seen from inside the array. There are 5 lines of speakers, each having either 5 or 6 channels. This configuration is combined in the provided breakout cabling modules to either connect directly to a provided DickinsAudio amplifier or provide 26x2 conductor terminations for any custom amplifiers.

[1] The tolerance is largely related to care in construction (seating poles fully) and setting the array to have neutral load. Thus at smaller scales the tolerance is as low as 1mm, and for very large arrays with load or drag it can be 20-30mm unless care is taken to determine the correct neural load position.

3. Speaker and Enclosure Specifications

The section provides details of the speakers which also serve as the vertex construction. The speakers are based on a 130mm diameter sphere to achieve good symmetry in the polar response. A 3" driver was selected to have suitable full range response from 100Hz to 15kHz. This driver has a good consistency and power handling. The characteristics of the driver in isolation is shown from the manufacturer data, and this is consistent with measurements in the DickinsAudio lab. Note that the final speakers with provided calibration can achieve a near perfect flat response at the center, and these speakers provide an effective response for the intended applications.

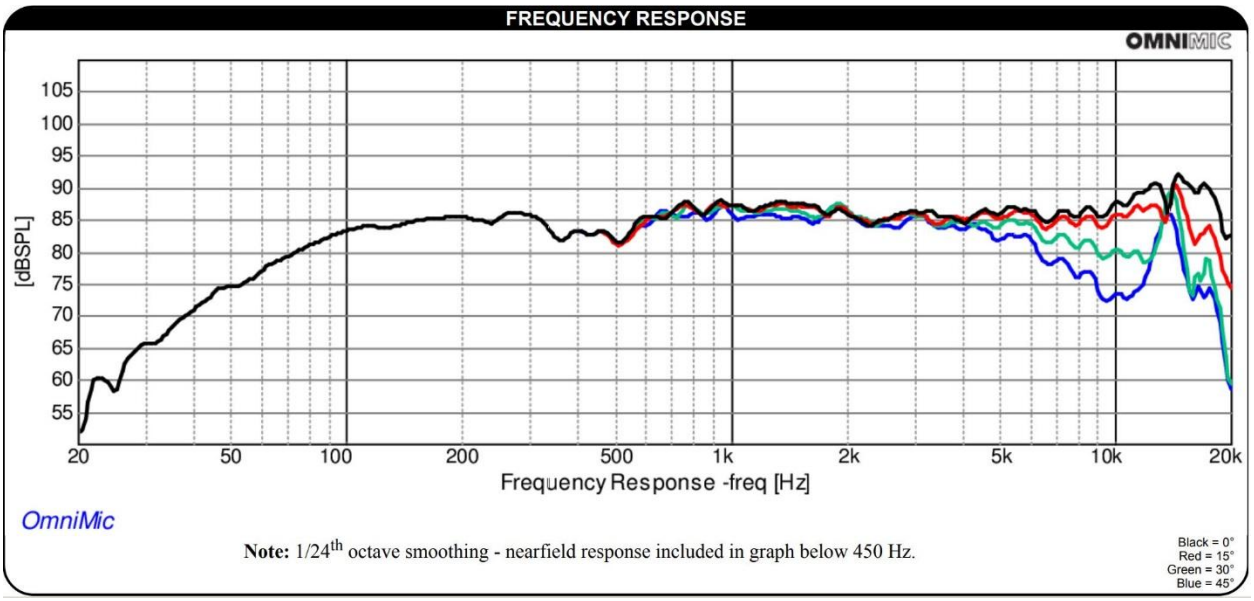


Figure 4 Speaker driver response taken from Dayton Specifications - PC83-4.

The speaker enclosures are designed with both the response and structural requirements in mind. Significant research and development and design iteration has led to the feasibility of additive manufacturing at scale, which allows for the complex geometry whilst retaining tested strength, consistency and low porosity (air tight). The following specifications are given for the enclosure.

- 130mm diameter spherical shape closely matched to the speaker driver edge.
- PLA – single piece high temperature layer bonded (240 degrees), complete airtight seal, 0.32mm layers
- PLA material weight 340-380g
- Interior volume 500ml
- Silver Butyl rubber viscous sound dampening – approx. 50g
- Polyester Speaker fill – low density approx. 300ml
- Proprietary innovative design of enclosure back wall designed to break up standing waves and resonances
- Individually tested for manufacture quality, airtight seal, and structural integrity

The enclosures can be printed in alternate colors or with a custom logo as an additional option. This will increase cost and lead time, though we are open to discussions as the additive manufacturing allows for endless possibilities. An example of the 5 point vertex is shown in the following figure.

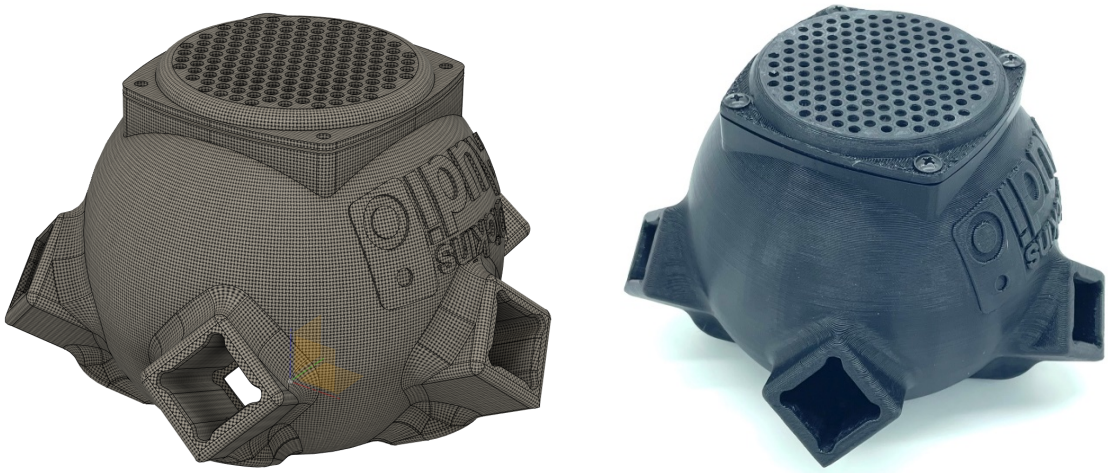


Figure 5 3D model for printing and an actual printed speaker enclosure.

For mechanical strength, the units are printed with additional outer layers and high density honeycomb infill. A cross section of an actual print is shown in the following figure. This also shows the innovative design of the enclosure back wall which is designed to break up standing waves and resonances. A speaker grill is included for protecting the speaker drivers and is acoustically transparent across the operating range of frequency and cone excursion.

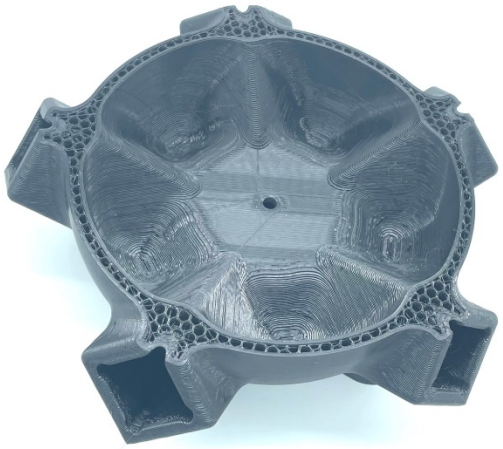


Figure 6 Cross section of enclosure printing showing the convoluted rear wall and the internal honeycomb structure.

Once fully constructed the speaker responses can be characterized in the array. The following three figures show the response of the speakers for a full 26 speaker array from a calibration report (sample available). The initial data shows the natural response, where on axis we see the characteristic dip and then 7dB boost on axis at the highest frequencies. This peak is not as prominent off axis. The second figure shows the use of a single third octave EQ preset or filter across all speakers. The slight variation in the 3 and 5 point enclosures is detailed. Note the vertical scale represents and shows detailed response with 5dB a division. The final figure shows a calibrated set with individual filters provided. The lower frequency response is a balanced flattening to keep filters short and perceptually effective.

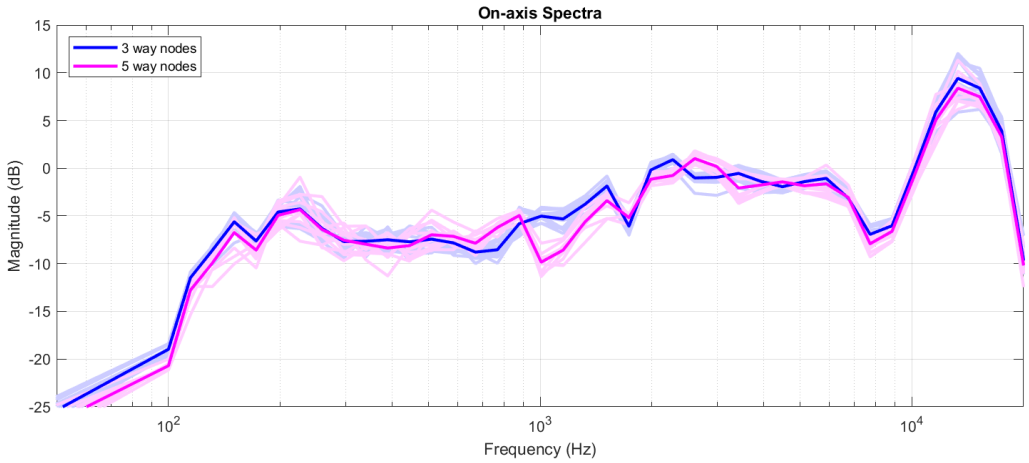


Figure 7 Raw response of the speakers measured at acoustic center of array. 26 responses with mean curve.

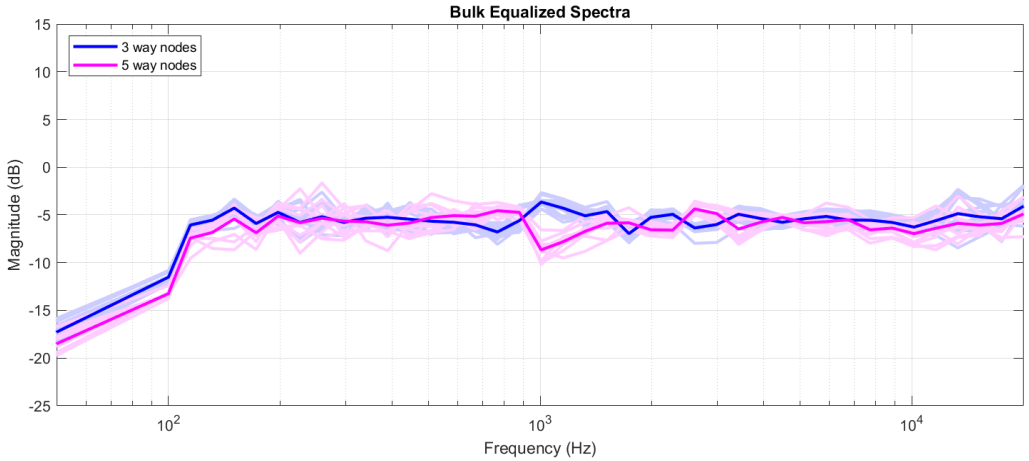


Figure 8 Response achieved with a single filter used for all speakers. Response has <2dB stdev fom 100 to 15kHz.

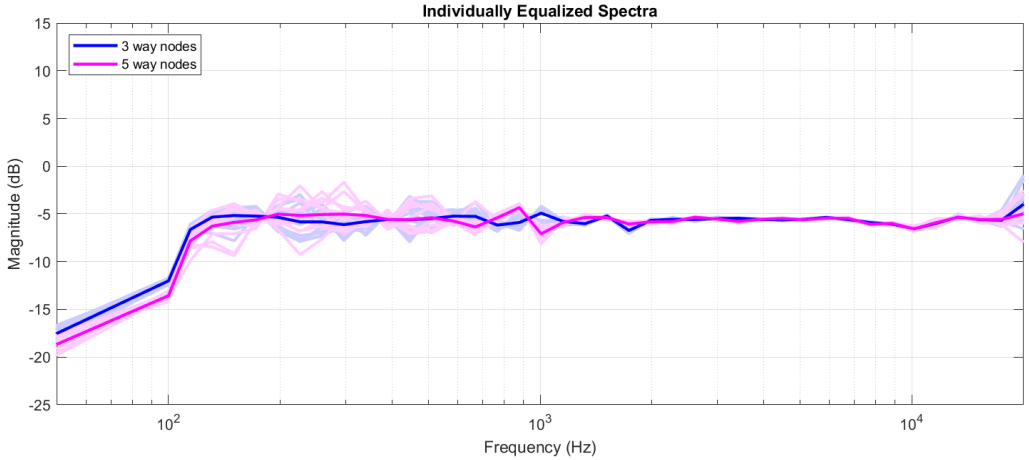


Figure 9 With individual calibration, the response is consistent <1dB from 1kHz to 15kHz.

4. Poles and Locking

The structural members proposed for this size are 20mm square section 1.6mm extruded aluminium. The inner dimension is 16.8mm and suitable for running the modular cabling between speakers. There is also the option to flock the poles or insert them into K Flex insulation foam should you wish to make the poles less visually intrusive (see image below). The poles slide smoothly into the enclosures once care is taken to properly align the poles (do not force). Once inserted there is a rigid stop felt at the end. A 5mm grub screw is then used to hold the pole and prevent it from sliding in and out. Since the pole is inserted with a tight fit, it is not necessary to overtighten the grub screw as it is only holding the pole from axial sliding and is not the main load bearing site.

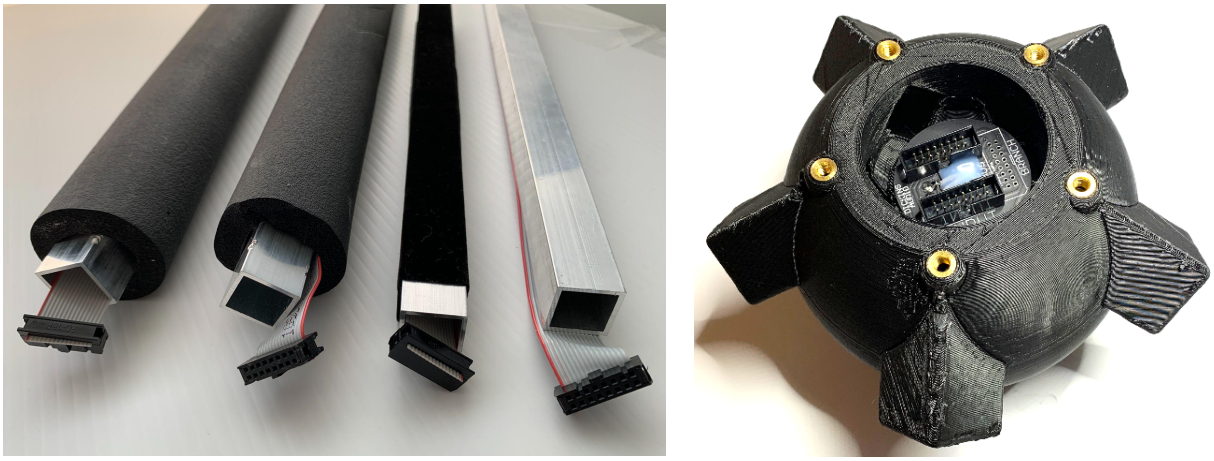


Figure 10 Options for cabling and cladding for the poles, and the rear of the speaker showing the cable connections and the heat insert grub screw holes. Caps are provided to cover the cable connection point (optional).

General load testing on a 1800mm array supported static loads of 150kg. For the 2400mm proposed design, with suitable safety margin, any structural load should be less than 50kg additional loading. The complete weight of the system is around 60kg, with additional weight for any casing. Once installed, it is advised that the structure be fixed off to a wall or ceiling at a few points for additional stability.

The speaker enclosures form the precise geometric registration of the aluminium square sections. These are precisely manufactured to a tolerance of 0.25mm and balance construction ease with secure fit. An additional grub screw is provided for fixed installation and additional structural stability. With care to secure all poles fully into the ports, the geometry and speaker positions will be accurate to about +-10mm.

5. Modular Integrated Cabling

The cabling is achieved through point to point chain connections using IDC 16 way connectors and heavy duty 26WG 1.27mm ribbon cable. Up to 8 speakers are present on one cable run. This solution allows each segment of the system to be removed or returned easily. The directed design ensures there is only one cable type, and more reliable mechanical fixtures and electronic connection. The solution named the OctoBus™ is able to take advantage of both line and branched wiring, which facilitates minimal cable in the system.

The speaker cable has resistance of less than .2ohm per meter. On a 2400mm design, the ohmic load from wiring and connections from the amplifier port to the voice coil will be <1Ohm representing a wiring variance of around 1dB standard deviation in output power, which is roughly also expected with speaker driver variance. It is recommended for any array that at the very least broadband gain calibration of the speakers is performed, at which point this ohmic variation and load of the cabling solution is moot, and the benefits of the OctoBus in terms of reliability, simplicity of wiring, time to deconstruct and reassemble, and creating variations in geometry[2].

[2] More information on the Octobus is available on request.

6. Integrated Amplifier

Cost effective amplifiers have been designed to suit these arrays. Each channel can sustain 30W with the overall power depends on the supply. In most cases, for content with low frequency management and thus energy from 100Hz and up, adequate power is provided from one or two 90W modular supplies. The amplifiers are designed and tested to handle up to 250W each. For music program content, this is effectively a 50W peak for each speaker, and comfortably achieves >110dB peak sound levels at 2400mm diameter when multiple speakers are in use. If a higher dynamic or sustained power is critical, there are options of parallel amplifiers (please contact to discuss), or the option of a wiring breakout to use any other amplifiers.

The DickinsAudio amplifiers receive digital audio input over ethernet using Dante or AES 67. The Dante hardware used provide precision timing with all speakers being aligned within 200ns (<<1mm) even when distributed across arrays. A full data sheet for the amplifiers is included on the following page.

7. Dismantling, Portability and Reconstruction

The array nodes are designed to withstand a reasonable number of disassembly and reconstructions provided care is taken to not impact or pierce the enclosures. If the array is likely to be moved only occasionally, the small road case is advised as a reusable way of packing and or storing the equipment. If the array is targeted for moving regularly or for demonstration or show usage, a large case design is recommended which allows sections of the array, each having 5 speakers, to remain assembled and cabled. This then means the array can be setup without any time consumed in feeding cables through the frame and reduces wear on the equipment.

The example video of the 1800mm array shows the five pieces being pre-assembled and then the final stage of assembling the full array. The five intermediary parts can be retained with most wiring remaining intact. In the case of this size array, these pieces are approximately 1700x900mm and will stack neatly into a 1000mm high case.

8. Instruction Manuals and support

Material to support setup and installation will be provided, including a video showing the detail of pre-assembling the five main pieces and correctly securing the cabling.

9. Construction, Testing and Site Delivery

The array is shipped in re-usable packing, as three parts – two sets of speakers, and one set of poles. This keeps each item under 20kg. The suggested assembly approach is shown in a video at https://vimeo.com/user103144106 A set of images from this instruction video are shown on a following page.

Starting by locking a ring of 10 speaker together at the bottom, the array is quickly built up to the full set. Care must be taken to ensure the correct speakers are put in place (if using individual calibration filters). Using the correct speaker placement as numbered also helps to correctly cable and test the array.

If the array is ordered with the calibration option, it will be fully assembled, tested and calibrated prior to shipping. As such, the grub screws will already be installed and some wear will be seen in the speaker pole holes, and minor burr marks on the poles. These are all immaterial functionally or aesthetically. If the calibration option is not selected, the speakers will be individually tested and the poles and grub screws will be in a separate bag. Tools are provided for all the grub screws.

If selected, the additional cable kit allows for more flexible options of cabling and re-use of the speakers. Generally, if care is taken, the cables can be re-used and so the system can be constructed and reconstructed many times. Since each reconstruction can place stress on the cables and speakers, and accidents happen, a spare of each speaker and a few spare cables are included in the base kit. Additional replacement speakers are readily available, and cables can be made with any IDC 2x8 plug and cable.

10. Construction Sequence

These images are taken from the instruction video at https://vimeo.com/user103144106
Note that the packaging may vary from what is shown in this video. Newer arrays are in split boxes to reduce the maximum weight in each package.

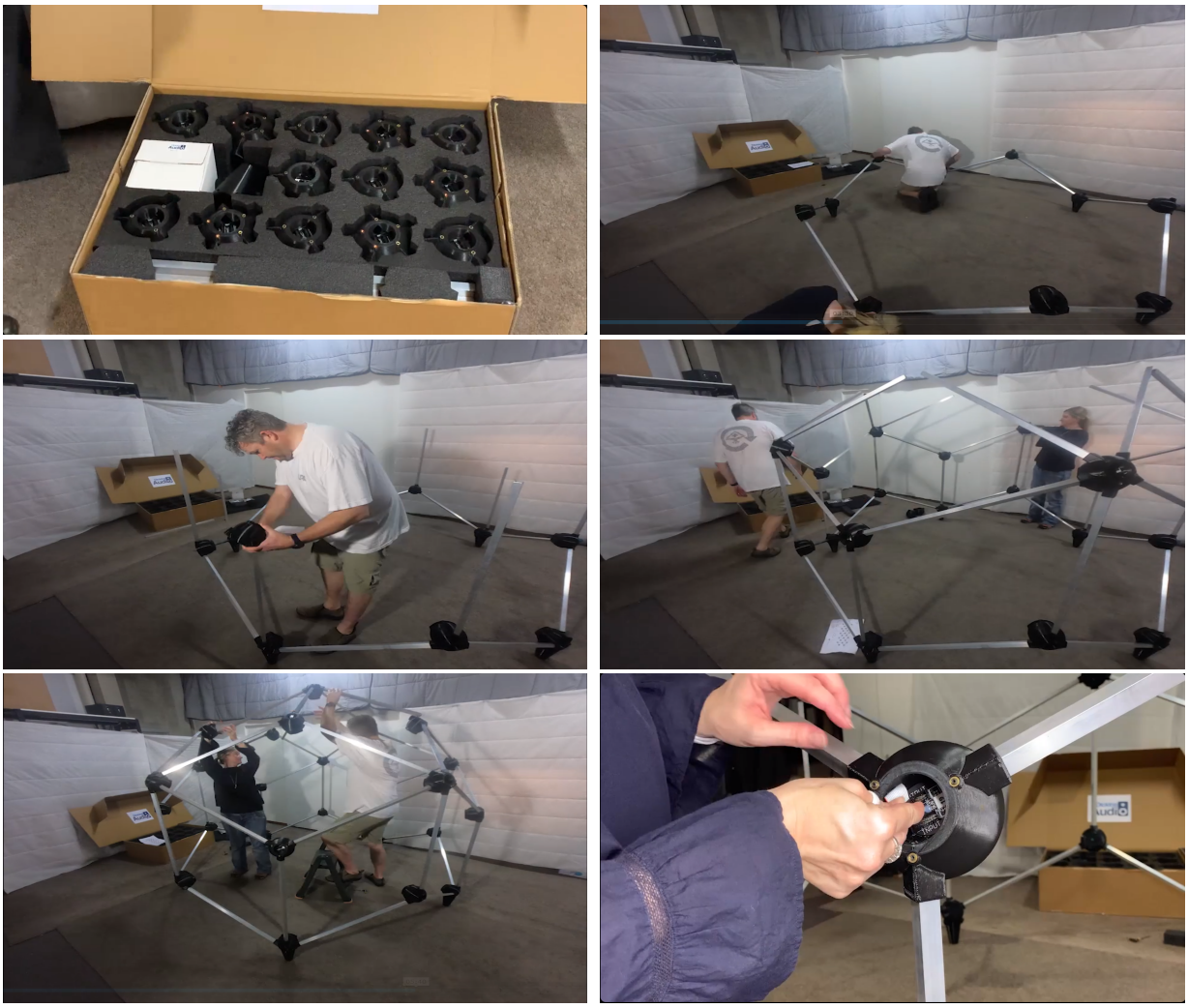
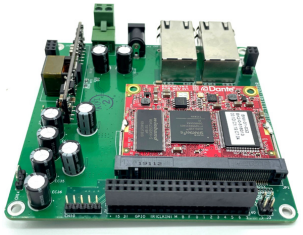


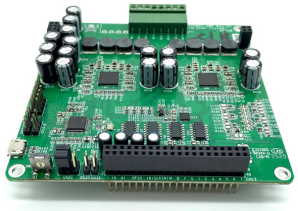
Figure 4 Stages of construction over a time of around 40 minutes for a 1800mm array. Additional time is required for running cables through the interior of the frame. A reasonable estimate of time for setup would be 2-3 hours.

DAMP16 16 Channel 40W Amplifier
Dante Input at 250us Latency
802.3at 30W PoE or 24V 15A

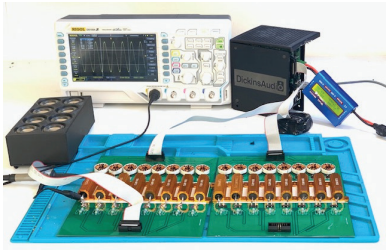
Designed for scale, these amps punch well above their size. Dante input provides convenient connection directly over ethernet to your PC or other audio gear.



Dante Base Board



Amps 2 x Infineon MA-12070P



Full load stress testing

PRICE	$2,299	$2,499	AUD
CHANNELS	16	16	
MODEL	DAMP16-90	DAMP16-250	
Peak Ouput Voltage @0dBFs	18V Soft Clip	20V	
Output Voltage RMS @-6dB rms	10V rms		Calibrated Independent of Power
Peak Power per Channel	40W rms		Brief peak or sustained 1ch per board
Peak Power Channels Sum	90W rms	250W rms	
Peak Power per Channel on PoE	15W rms		PoE Provides only 12V peak
Peak Power Channel Sum on PoE	20W rms		802.3at (Limited to avoid cutout)
Connectors	4 x 8 way 3.81mm Phoenix Connectors		Adaptor option for 2 x IDC 16 Ribbon
Frequency Response	10 Hz - 22 kHz +- 0.5dB		With Dante 48kHz Input
THD	0.01% @ 1kHz, 10W typical		Subject to Power Sum Limit
Cooling	Passive Convection with Vented Enclosure		Must sit in open space, not covered
Operating Temperature	Suggested ambient < 30degC (90 degF)		Higher ambient may lower power sum
Protection	Inidividual amp thermal and 5.5A current over		Momentary Shutdown - Click
	Full system thermal shutdown		Full Shutdown whils cooling
	Over-current limit from PoE to Amps		PoE kept alive, amps will clip
Dimensions - W X D X H mm	127 x 118 x 122		Case is PLA and Acrylic
Power Supply Provided	19V 90W DC Plug	24V 250W 5mm Phoenix	80-260V AC Input
PoE Option	802.3at Provides Stability and addidional power		
Required Network Switch	>= 100Mb 1Gb Suggested Ensure EEE disabled		Unifi Equipment Preferred

contact : sales@dickins.com

11. Additional Options

Some detail is provided here on additional options that can be supplied with an array at an additional cost.

Breakout for Arbitrary Amplifier
This kit maps the 5 array lines from the array out to a set of 26x2 pads for 3.81mm connector pins or headers. Since there are some varieties of this kit, please call to discuss your exact needs which may be accommodated with a particular variation.

5M Array Extension Cable
If using a custom amplifier, or moving the DickinsAudio amplifier away from the array, these cables provide 5m of IDC 16 cables terminated with a female and male end so they can be used to extend the cables coming out of the 5 array points.

Pre-ship Construction and Individual Speaker Calibration
The array will be constructed and measured on site at DickinsAudio and this will provide individual response data and corrections for the array. Smaller arrays can be measured in anechoic space, whilst larger arrays will be measured and time gated to achieve a suitable speaker equalization response. This calibration will also factor in any attenuation in the cables, and any minor differences in the amplifier responses to achieve a 1kHz variation less than 1dB. A full report is provided, and a sample report is available on request, or has been attached to this information brochure.

Custom Cable Making Kit
This includes everything required to make a set of cables, which will serve for any system that may be moved or require alternate sizes and cabling. Since the system uses standard 2.54mm (0.1”) pitch IDC connectors, this equipment is generally available from any electronics supplier, however the IDC cable provided in this kit has a substantially heavier wire gauge than normal to provide the lower Ohmic load and power loss in the cables.

Alternate Length Pole Kit
This kit will duplicate the poles and all cables so that the array can be constructed at an alternate size. This is useful for an array that needs to serve as both a smaller mastering setup, and an occasional public demonstration. The cost is the same for all lengths, given the main cost in these kits is the construction and testing.

Foam Sleeving or Flocking
As was shown in Figure 10, the poles can be modified for aesthetics or function (bump protection).

Feet For Base Speakers
The option for feet provides plastic forms that can be connected onto the base speakers. These provide a sacrificial surface for any wear, and also help by lifting the entire array up for smaller sized arrays. The feet are shown in the instruction video for a 2400mm array.

Contact Details:

Thank you for your interest in our 26 speaker array. For further information or to discuss your requirements, please feel free to reach out over email. k@dickins.com

Karen Dickins