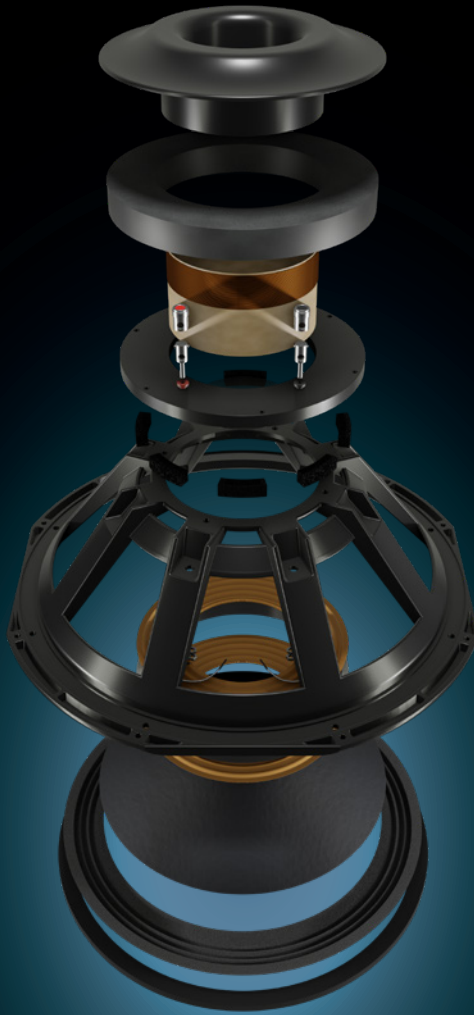




OUR GUIDE TO
UNDERSTANDING LOUDSPEAKER SPECIFICATIONS

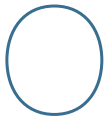


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FANE

Fane loudspeaker technology sets the global standard for high-performance sound systems, offering unmatched clarity, efficiency, and precision across every frequency.



ur component loudspeaker products are the culmination of intensive research and near 60 years experience of designing the finest quality loudspeakers without compromise.

Fane has a heritage of delivering a quality of performance, reliability and sonic excellence demanded by the most discerning of audio professionals.

Frequency response and sound pressure levels are scientifically calculated and adjusted to provide accurate matching and balance over all frequency bandwidths, at overall high efficiency and with negligible distortion.

Driven by an uncompromising quest for excellence, the Yorkshire-based, family-owned and managed company is committed to building the very best professional loudspeaker drivers. All products are designed and engineered by our UK R&D team, responsible for designing some of the finest quality audio components in the pro audio industry.

Any single specification is not the distinguishing feature of any one of our products; each model represents the optimised combination of parameters and technical design to achieve optimal results for various applications and cabinet enclosure designs.

The Fane product line is conceived as a complete range, designed to integrate as an optimised combination of components to provide a harmonious blend of

bass, mid and high frequency drivers, seamlessly covering all sectors of the audio spectrum. Hand-crafted using only the finest materials for an understated British flair and style. Blending the best of British design, our products represent the ideal combination of design technology, engineering excellence, craftsmanship and refined performance, which underscores our commitment to achieving the epitome in world-class audio engineering.

Our conservative approach to technical specifications such as power ratings ensures that every parameter is accurately defined without making exaggerated claims or stating a peak figure that does not accurately reflect the performance of the drive unit across its recommended working bandwidth. This approach, one born of a desire for providing audio professionals with accuracy and consistency, reflects our ethos of understated British engineering excellence and is a hallmark of Fane's commitment to quality.

INTRODUCTION TO AES POWER HANDLING

Reproducing an audio signal is something almost all of us take for granted; what appears simple on the surface suddenly becomes a lot more complicated on further investigation. Part science, part art, it's a world filled with confusing terminology, conflicting opinions, misunderstanding drenched in creative marketing. Even seasoned professionals do not seem to fully agree on the various approaches to designing and building loudspeakers. Although the basic principles of the loudspeaker are relatively easy to grasp, designing one and optimising it for the best sound is a difficult process. What often appears perfect in theory doesn't always translate as predicted in the real world.

There is so much to consider in Pro Audio than can be covered in this document. Rather than an exhaustive guide on the subjects covered, our goal is to provide insight into the methods, approaches and perspectives of Fane based on our near 60 years experience designing and manufacturing pro audio transducers. The aim is to provide inspiration for audio enthusiasts from which to build, research and develop further. As such, this document contains a number of simplifications and may touch on some subjects without expanding further to that end.

It would seem generally accepted that a high power rating is desirable and a sign of quality. Many manufacturers exaggerate or draw attention to 'big numbers' that sometimes have the greatest influence on driver choices. In reality, the figures themselves can mean little and be misleading in terms of a speaker's actual performance compared to other specifications. The result of being misled by power handling ratings is that it does not allow 'like-for-like' comparisons between similar products. Fane choose to give realistic figures that are proper and correct, each measured using approved industry standard practices.

Loudspeaker power ratings describe the amount of continuous power that can be dissipated in the form of heat without damage. While it may appear that more power dissipation is better, this is only true if the method used to achieve it does not compromise the efficiency of the loudspeaker. Understanding the two main causes for driver failure can help when it comes to understanding power ratings: Thermal and Mechanical.

Thermal Failure

Thermal is the most common of failure modes, and often unfairly blamed on the loudspeaker driver itself. Failures occur from too much current when an amplifier's

***TIP:** If you have any questions or doubts, our Fane appointed representatives, who possess years of combined experience, are perfect to advise and guide you. Get in touch, we're happy to help! info@fane-international.com*

continuous output reaches beyond the heat dissipation capabilities of the loudspeakers voice coil. Loudspeakers are very inefficient devices, on average 0.5-5% of power supplied is converted to sound; the rest is converted to heat. If a loudspeaker is unable to dissipate that heat quickly enough the speaker will soon fail. One of the main causes of driver failure is a clipped or square-wave signal being sent from an amplifier. At the same voltage, a square wave represents double the power of a sine wave. Essentially, the AC signal is more sustained and therefore presents a load similar to that of a DC signal, hence it is sometimes referred to

wave output. At the peak of a sine wave, the voice coil of a speaker is pushed out and therefore if a square wave is applied, the voice coil is spending more time out of the coil gap. This leads to a poor heat distribution through the magnet, which overheats the voice coil and burns it.

Other causes of thermal failure can occur when a driver is sent a signal from a misconfigured system outside of its operational bandwidth; input power is then purely dissipated as heat. Enclosure designs without adequate consideration for ventilation can also cause problems or if DC voltage is

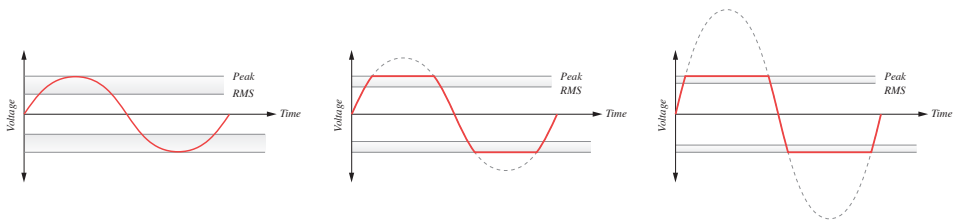


Fig. 1: Showing a 1W sine wave going into clipping. Notice that the voltage is sustained for longer periods at the waves peak as becomes a square-wave.

as 'DC burn'. That means that the speaker has to dissipate twice the amount of heat. Amplifiers are rated at the power they can provide with a sine wave type signal. When that signal is pushed into a square wave, the amplifier can often output more than its rated power.

In most cases, this fault is caused by the amplifier 'clipping' the input signal due to the user trying to get more out of the amplifier than it is rated for. This causes an increase in input level to the speaker, therefore a larger sine wave. If this sine wave is pushed too hard, the amplifier will 'clip' the top and bottom of the wave and produce a square

applied to the coil (most modern amplifiers have DC protection circuits so this kind of fault is rare). Overheating may also damage adhesives and other parts that can also lead to mechanical failures.

Mechanical Failure

Mechanical failure occurs when the transducer cone or diaphragm, voice coil or suspension systems are forced to physically move beyond their limits (X_{max} / X_{mech}). Typically, this is the result of amplifier peak voltage being too high. The result is over-excursion that can cause the coil to move out of the voice coil gap completely, or hit the back plate – known as 'bottoming-out'.

This causes destruction of one or more of the software components or voice coil. Sometimes they may continue to work but performance is usually severely affected with audible results such as hissing and rattling. Misconfigured cabinet designs can also cause excursion problems.

HOW WE DETERMINE POWER RATINGS

How much power a speaker can handle gives no direct indication of its performance at full power or how loud it will be. It just tells you that's how much power it can survive. Many methods exist for determining the maximum input power. All of them have merits, and similar attributes yet yield different results. Fane specified nominal power ratings are governed according to AES2-1984 standards that test both thermal and mechanical properties of a driver to the limits. Key conditions of the test are as follows:

Transducer Mounting: Low frequency drivers are tested in free air orientated in the horizontal axis. Compression drivers are mounted to a suitable industry standard horn or a device to reasonably simulate the acoustic loading of a horn.

Signal: Transducers under test are driven with a band of pink noise extending one decade upward from the manufacturer's stated lowest usable frequency. The input signal shall be bandpass filtered at 12dB per octave with Butterworth filter response characteristics, and the peak-to-RMS voltage ratio of the noise signal supplied to the LF driver shall be 2:1 (6 dB Crest factor).

For instance, a 35-350 Hz range, was used when rating our 1300W (AES), FC-185F03 sub bass driver.

Calculation: ($P=V^2 / Z_{min}$) Power shall be determined as the square of applied RMS voltage, as measured with a "true RMS" voltmeter, divided by Z_{min} . The rated power of the device shall be that power the device can withstand for 2 hours without permanent change in acoustical, mechanical, or electrical characteristics greater than 10%.

The successful test conditions will therefore be derived AES nominal Power rating for all Fane Drivers. However, in a correctly optimised enclosure featuring good cabinet assistance, Fane drivers often out-perform their nominal rated AES power ratings and also outperforming competitor's offerings of the same nature even with their higher rated powers.

PEAK POWER

This is the amount of power the speaker can take for very brief periods at a time. In a sine wave, the relationship between peak and average power is 2:1 (the peak voltage is 1.414 - the square root of 2 - times the RMS voltage, which doubles the amount of power produced in a given load).

Most speakers will briefly handle signals with greater peaks (Fane's Peak Power is listed on our specification sheets as being a calculated four times greater than the AES Nominal Power Rating as a guide to recommended amplifier power). Peak power is not representative: typical content last no more than a few milliseconds.

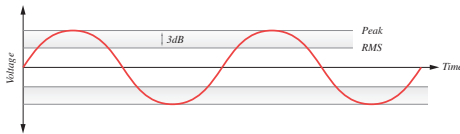


Fig. 2: Illustrating a sine wave audio signal RMS and Peak.

RMS

Root Mean Square is used to compare the AC power to the equivalent DC power required to provide the same heating capacity into the load. In amplifiers and speakers this is usually measured with a 1kHz sine wave input. This is measured as a constant input signal. In real sounds however, the levels change all the time so this is the reason for quoting peak power. But this refers to only short bursts of input causing large outputs. An amplifier couldn't maintain a peak output constantly because of power supply, and overheating problems. You might see a 6-Inch home speaker rated as a 1000W Peak music Power Output (PMPO) but you try and put even 50W RMS through it and it will be destroyed swiftly.

PROGRAM / MUSIC POWER

Although having no specific meaning, it's generally accepted that it is the amount of power that a speaker can handle during typical music or 'typical program' (if there were such a thing) where frequency content and power constantly vary. Program power is typically given as twice that of the nominal power rating.

POWER Vs. PERFORMANCE

Everyone wants great, high-quality sound from their loudspeakers, sounds that fill a space with deep bass, rich mid range and sparkling treble. To us there is nothing impressive or beneficial in driving lots of power into a loudspeaker. The ideal loudspeaker should be able to produce the desired sound level using as little power as possible. We feel it is more impressive to get lots of quality sound with less applied power. Rather than reading a specification sheet and saying, "Wow, that speaker handles 5000 watts!" we think it's better to ask "Why do I have to use 5000 watts when Fane speakers can produce the same SPL level at 1000 watts?" Horn loading and other enclosure design techniques are methods of increasing loudspeaker efficiency, allowing more sound per the applied voltage (and ultimately the applied power).

As a woofer reaches its power limits, unless failure occurs there will be a point where the resistance of the voice coil rises faster than the power going into the driver and therefore produces lots of heat that the driver is not able to dissipate. This is called 'power compression'. It implies that the more power you put into the driver, the less output you get out. For this reason, it is a mistake to associate the power rating of the loudspeaker with its sonic performance.

Higher power ratings simply mean that a speaker is one of two things; firstly it is so inefficient that it needs excessive power to drive the coil. Or, secondly, it has such an effective heat dissipation management system that it is able to deliver high SPL

at the stated higher input power. Sadly, in the vast majority of cases the first option applies. Power ratings by themselves give no indication of efficiency in producing acoustic power, which is the purpose of the loudspeaker. Ultimately if you want more volume/ SPL performance you'll need to add multiples of your given enclosure design.

THE PERFORMANCE ADVANTAGE

Take this example. In a recent A/B test we performed with our sister company Precision Devices, PD.184NR1, 1000W (AES continuous) against a competitor's equivalent model that claimed 1500W. Both speaker specifications showed a sensitivity of 99 dB (1W/1M) over their working bandwidth. On paper at least, many would pick the higher power rated speaker, but this could prove to be an unwise choice.

In this particular instance, after incremental power tests, we discovered that in excess of 1000W the efficiency of the 1500W driver actually began to slope-off as a result of power compression, producing lower SPL while the lower power-rated PD model was rising in SPL to a +3dB difference.

AVERAGE SENSITIVITY

There is no industry standard practice for measuring loudspeaker sensitivity. As such manufacturers use different methods to define SPL output and this is when marketing spin often comes into play. 'Big' sensitivity numbers are shown in the most obvious places on a specification sheet, such as 99dB. Often large peaks found on a frequency response chart, that are outside a drivers intended working bandwidth and would be removed as part of a larger system network, are included which manipulates the truth to give a higher SPL figure. It's only on closer inspection in the darkest corners of some spec sheets that the true 'reference efficiency', band limited, sensitivity figures are found. Fane list average sensitivity figures that are calculated from the speaker's Thiele/ Small Parameters and take band limiting into account so as to give a true reflection. Take the graph below for example, it shows the same speaker rated in two different ways, 96dB to include it's true working range and 99dB that includes upper frequency peaks to increase the figure.

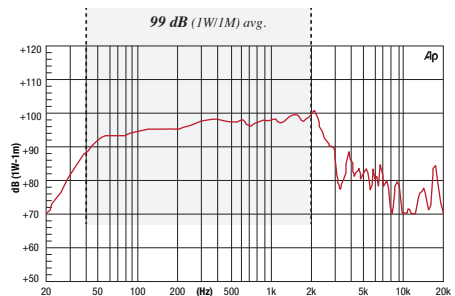
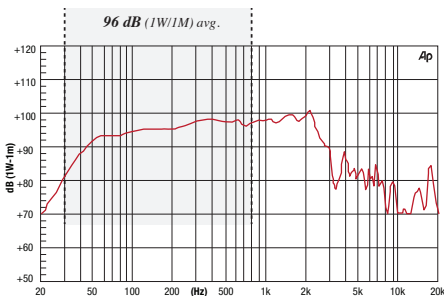


Fig. 3: Spot the difference... The same speaker can be rated almost twice as loud. Sensitivity ratings can be manipulated depending on the frequency bandwidth tested.

TIP: 3 dB of additional sound power from the same loudspeaker requires double the number of amplifier watts. It is commonly accepted that 3 dB is the smallest practical sound pressure difference detectable by the human ear.

If you want your sound system to be noticeable louder, you will need at least twice as much amplifier power or loudspeakers at least 3 dB more efficient.

That means if you have a 1500W amplifier and are considering replacing it with a 2000W amplifier you should save your money, as that is only a 1.2 dB difference. At least 3000W are necessary for a significant improvement in performance... if your current loudspeakers cannot handle that kind of power, you need loudspeakers with either higher power handling, higher efficiency or simply more loudspeakers.

CABINET DESIGN

Loudspeaker drivers are typically housed within a speaker enclosure, cabinet, along with associated electronic hardware such as crossover circuits and, in the case of active systems, internal power amplifiers.

The primary role of an enclosure is to prevent the sound waves generated by the reverse motion of an open chassis speaker's diaphragm from interacting with sound waves generated from the forward motion. As the front and rear sound waves are generated out-of-phase to each other, they travel different paths before finally converging at the listener's position.

Any interaction in the listening space introduces interference and distortion to the audio reproduction resulting in unintended effects such as echo or reverberation etc. This is especially true in the case of low frequencies, on which enclosure design mostly focuses. As such, a loudspeaker can't really be used without a cabinet of some type, or by mounting it into a wall or ceiling. Some designs attempt to take advantage of this behaviour, using the opposing forces to enhance sound and increase efficiency.

Most commonly made from wood, enclosure materials play a very important role in the quality of the sound, managing vibration induced by the driver frame and moving air mass within the enclosure, as well as heat generated by driver voice coils and amplifiers (especially where woofers and subwoofers are concerned). There are many types of enclosures, with various levels of

skill and knowledge required to design and construct each. From small full-range home 'bookshelf' enclosures to huge dedicated 18, 21 or 24-inch subwoofer enclosures for clubs and stadiums. Designs can vary from simple, DIY rectangular MDF boxes to very complex and expensive CAD designs that include composite materials, internal baffles, bracing, horns, bass reflex ports and acoustic insulation etc.

Enclosure design requires the use of specifications called TSPs (Thiele / Small Parameters). TSPs quantify a number of a loudspeaker's performance characteristics and can be used to predict the performance of a speaker in various types of enclosure. Thankfully there are a number of computer software tools available to help in this part of the design process.

Designers must ultimately learn to balance low bass extension, linear frequency response, efficiency, distortion, loudness and enclosure size, while simultaneously addressing issues higher in the audible frequency range such as diffraction from enclosure edges, the baffle step effect when wavelengths approach enclosure dimensions, crossovers, driver blending and time

alignment. All topics too vast to discuss here, subjects for further research and definitely not for the faint of heart!

CROSSOVER NETWORKS

A crossover network (Xover) is a device that divides an audio signal into separate frequency ranges, or bandwidths, ultimately routed to different drivers (speakers, tweeters, horns, etc.) In a multi-way audio system. By doing so, a crossover network serves two important functions;

- 1) It allows optimum system sound quality by ensuring that each speaker only operates with its intended bandwidth.
- 2) It prevents damage that would otherwise be caused by low frequencies being fed to midrange and high frequency drivers.

The degree by which a crossover network reduces the unwanted input above or below the specified frequency is known as the 'slope' and is expressed by the level of dB by which the signal is reduced for each frequency octave. The minimum slope

TIP: *What enclosure is best suited for you?*

That's for you to decide, it largely depends on the listening environment and objectives of the final system.

If you don't feel like designing your own enclosure, don't worry; Fane partners are able to offer full cabinet and crossover design kits that have been developed for select Fane loudspeaker drivers. Speak to your local representative for more information.

When you select a Fane loudspeaker component, you are choosing a meticulously crafted and optimised product designed by audio engineers, for audio engineers. Our emphasis on tonal character and meticulous craftsmanship sets us apart from the competition ensuring that our products redefine professional audio possibilities.



Product Shown: **IMPERIUM 18NDXL**

normally used is 12dB per octave, which is suitable for most normal requirements. However, some midrange drivers and high frequency devices require a slope of 18dB/octave. For such devices correct crossover specification is paramount.

There are two basic types of crossover:

PASSIVE CROSSOVERS

Passive networks consist of electrical components that require no external power supply. Connected between the amplifier and the loudspeaker they are normally located within the enclosure. When using passive crossovers the power proportion to each bandwidth varies in accordance with the crossover frequency.

ACTIVE CROSSOVERS

These are electronic devices that are connected before the amplifier stage. The frequency spectrum is then divided before it is amplified. Each loudspeaker is then fed with it's own bandwidth by its own amplifier channel.

In sound systems where less than 500 watts per crossover network is employed, the acceptable performance and costs of a passive crossover is normally preferred. For larger systems we advise the use of active crossovers since single active crossovers can drive a multitude of amplifiers. Perhaps more so, active crossovers usually incorporate a range of adjustment which can be very useful for optimising performance on-site.

AMPLIFIER SELECTION

Amplifiers can be highly specific and technically complex pieces of equipment. Sorting through the specifications and terminology can be confusing when selecting the correct amplifier and power requirements. When most people are asked what they want or expect out of a premium sound system, their answer is almost always "more power". These days amp power is relatively inexpensive yet prices and quality vary widely. While saving money is always desired, low-quality amps can contain component parts that introduce unwanted signal noise and effects that can have a massive impact on an otherwise outstanding system. We recommend the use of high-quality amplification equipment (with protective circuits), as typically they can improve sound quality, providing increased response, sensitivity and lower distortion due to lower interference or noise introduced by the other electrical components etc. Lookout for high THD or Total Harmonic Distortion, the lower the figure the less distortion. Look for figures below 0.05%.

WHAT IS THE APPLICATION?

Generally working out how much space you need to fill with sound and how many people will be in that space is a good place to begin. Will you be playing music in a local bar? Blasting out heavy metal in a 2000 seat stadium? Or just powering a system to play as loud as possible? This information will determine the best system design and setup to use for that environment. Smaller venues will obviously require less equipment than you would

need for a larger club or concert. (Don't forget, people absorb sound too. The larger crowd, the more power you'll need to compensate for absorption).

HOW MUCH POWER DO YOU NEED?

Every Fane product has a technical datasheet that is available in our product catalogues or on our website www.fane-international.com. First take note of the transducer Nominal Impedance specification. Typically it will be 8 Ohms. Then look for the Continuous Power Handling or AES Power Rating.

If you are able to prevent the power amplifier from clipping the signal by the use of a limiter within the signal chain, we suggest amplifier power of (Program Power) 2-times the transducers AES Nominal Power Rating per channel. This provides +3dB crest factor of 'headroom' for short-term transient peaks in the audio signal. For greater protection we recommend (Peak Power) 4-times that of the transducer's AES nominal power. However, audio signals can have peaks that are from +6 to +25 dB above the RMS level depending on the source input type. Some larger applications may require much more power to handle peaks without distortion.

IMPEDANCE

If you intend powering multiple cabinets from any single amplifier channel you will need to consider loudspeaker impedance. Modern PA amplifiers are designed to handle different resistance loads depending on the system design, the most common are 4, 8 or 16 Ohms. Optimum system performance will be obtained if the total resistive load (or impedance) of the loudspeaker or multiple loudspeakers is exactly correct for the amplifier. If it is not, a mismatch occurs. If the total loudspeaker impedance is too high, the power delivered to the loudspeakers will be reduced. If the total loudspeaker impedance is too low, the power delivered to the loudspeakers will be higher, which can overload your speakers and damage the amplifier.

Any number of loudspeakers or systems can be connected to one amplifier provided they are correctly wired so that the final impedance presented to the amplifier is an exact match. Multiples of loudspeakers can be connected together by three different methods, Series, Parallel and a combination of the two, Series/Parallel. Impedance (Z) load, in Ohms, is calculated by using the following formulae (see fig. 4, P.14, for examples):

***TIP:** Every part of the signal chain is important, and as such is only as strong as it's weakest link, so quality where possible is recommended. Consulting with a professional is always recommended for those unsure of their mechanical or electrical abilities. Our sales partners are able to provide excellent support and advice on amplifier selection and setups.*

Series Connection:

$$Z_{Total} = Z_{(speaker 1)} + Z_2 + Z_3 \text{ etc...}$$

For Parallel Connection:

$$\frac{1}{Z_{Total}} = \frac{1}{Z_1} + \frac{1}{Z_1} + \frac{1}{Z_1} \text{ etc.}$$

For combined Series/ Parallel, calculate the impedance of each similarly placed group of loudspeakers and regard the total impedance as being that of a single loudspeaker with a single impedance, calculate the total combined impedance using the formulae above.

In multi-way systems using passive crossovers, it is important that each separate frequency bandwidth of the system should present the same impedance. For example, in a system with 8 ohms total impedance, it is important that each of the three divided

enclosure sections - bass, midrange and treble - should individually have an impedance of 8 ohms. If each individual section comprises of more than one drive unit, the drive units in that section must be connected to present a total section impedance if 8 ohms. There is, however, an exception to this rule, in respect of the treble, high frequency section only. At frequencies above 3 kHz it is possible for the treble section to present a higher, but never lower, impedance than the other sections. The effect of higher impedance here is a decrease in sound output level but an increase in power handling capability, proportional to the miss-match ratio. If a 16 ohm compression driver were fitted into an 8 ohm system, as described above, the power handling capability of the treble section would therefore increase by a factor of two.

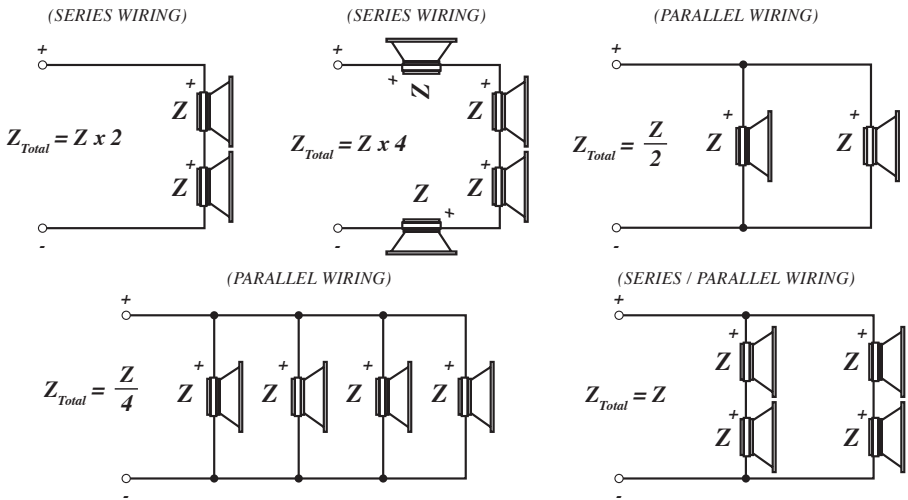


Fig. 4: Illustrating various wiring configurations and the formulae to calculate their load.

REPLACING AND UPGRADING PA SPEAKERS

Fane offer a wide range of loudspeakers suitable for the vast majority of sound reinforcement enclosure designs, ideal for upgrades to stock loudspeakers, custom cab designs or replacements for damaged drivers.

Identifying the correct driver or comparing two loudspeakers can be difficult, often with manufacturers having different testing methods or figures that only become clear about how they were achieved when delving deeper into the small print. While power rating is typically the first parameter to be looked at, there are other parameters that probably bear more important consideration such as Sensitivity and Impedance. Here are a few simple things to look out for when choosing a replacement speaker:

- What is the speaker's application? Sub bass, bass, mid etc?
- What are the physical dimensions of the speaker?
 - Such as chassis size and overall depth.
- Look for power handling and impedance ratings that match closely to the driver you are replacing, but beware of the figures.
- For best performance, try and select a driver that displays similar sensitivity (dB), Frequency Response Range and also check excursion capabilities (Xmax / Xmech / peak-to-peak).
- Check the loudspeaker chassis fixing hole PCD positions and baffle cut-out match that your enclosure (if you are not willing to cut new holes, that is!)
- Of course there are many more things that can be checked and compared; however, this list serves as a quick starting point.

THIS IS JUST THE BEGINNING...


Achieving consistent high-quality live sound can be a challenge. Your choice of PA speakers can determine whether you're mixing to make something good sound great, or struggling to solve sound-reinforcement problems. So, now you've got a general idea about what types of speakers you'll need, call your Fane representative, and we'll help you determine what your best options are. Don't forget, there's much more to learn and at Fane we're here to help you on your journey, regularly visit our website, www.fane-international.com for more handy guides and articles.



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