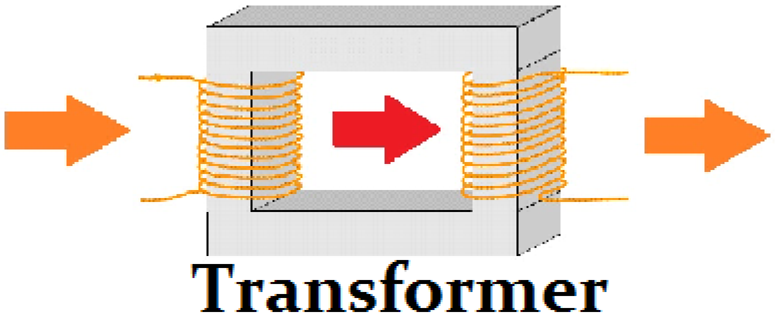
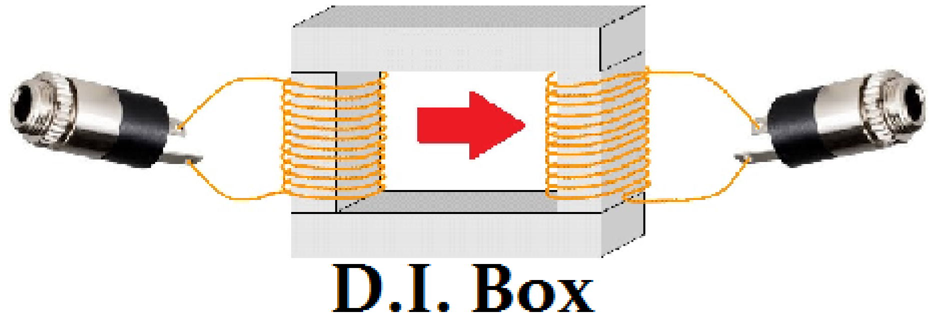
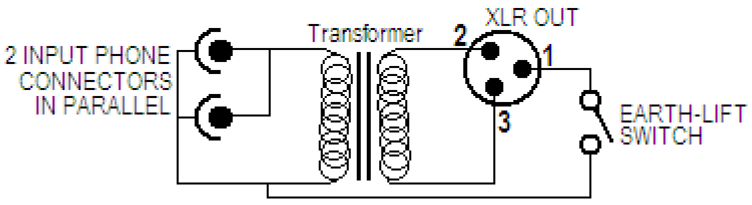
Sound System Advanced

✝ Church Audio ✝

Direct Input Box construction

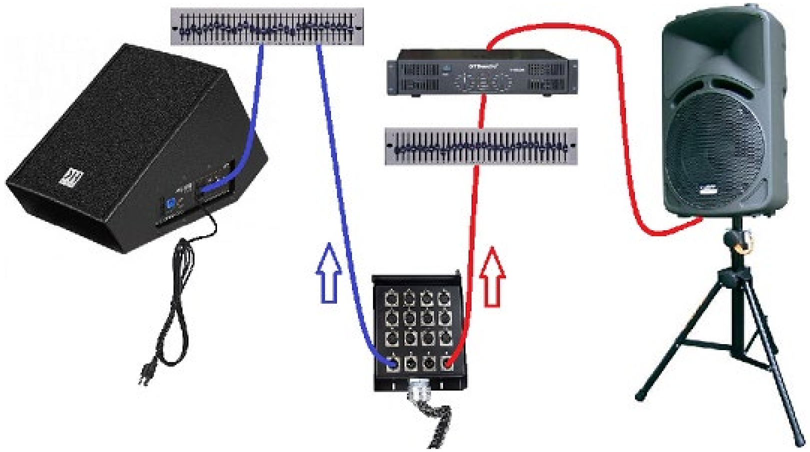






Here is the circuit. The cost to make it yourself will be a fifth of what you pay in a shop. You can buy miniature audio transformers from electronics shops for very little, or you can improvise using a household electricity transformer. Try it one way, then reverse it and try again. Sometimes going into the fine secondary wires and coming out the thick primary wires performs better.

Implementing a Graphic Equaliser

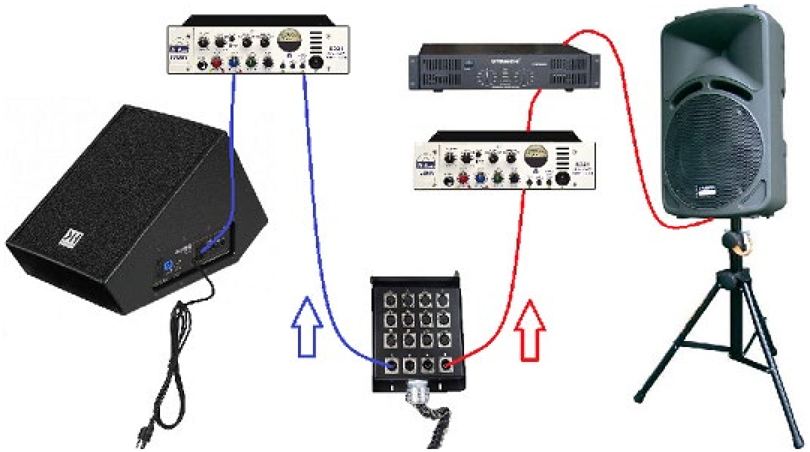


When you work in a venue that is all shiny varnished wood, it will make your sound bright and ringy. When you work in a venue that is all carpeted and dampened it will make your sound dull and muffled.

We compensate for venues that 'colour' our sound by placing a Graphic Equaliser (31 band) in the line to the Front-of-House Loudspeakers. This lets us equalise the overall sound to adjust for the venue influence.

Of course, it also gives us the opportunity to lower any naughty 'squeal frequencies'.

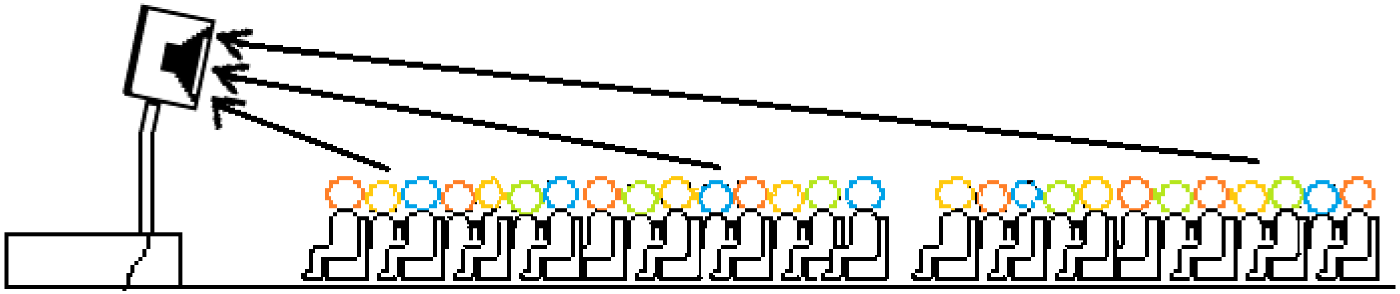
Implementing Compression



A slight compression on the signal going to a Loudspeaker gives more punch and clarity to the sound, and makes everything more audible.
'*Slight*' compression is the keyword!! If you compress too much you will cause squealing.

Using the *Limiter* feature on your Compressor to catch the extra high peaks is always a smart thing to do. It protects your Power Amplifier from blowing up (very expensive exercise) and it stops your Loudspeaker Cones from tearing (not very pleasant either).

Loudspeaker Placement



1. RAISE. If we place a Loudspeaker Cabinet on a stage at the same height as the congregation then the first row will hear a great sound. Unfortunately, people absorb sound, and high frequencies are directional and can't wrap around people, so from about the third row back the high frequencies will have been absorbed and the congregation will only hear a muddy mixture of mid-range and bass frequencies, and it will be hard to make out the words.
The back row will keep shouting "Turn it up! We can't hear!" Of course, the back row can hear… it's loud enough… but they can't make out the words because it's just a muffled confused sound (and volume won't solve that).
You must always raise Loudspeaker Cabinets so that the sound is beaming out to all the listeners, and not being absorbed by the congregation in front.

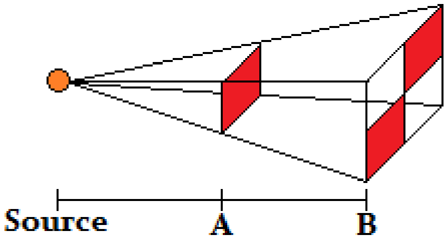
A Loudspeaker Cabinet should be raised up where everyone can "see the cones"… that means the sound will be arriving directly to their ears.

2. AIM. One of the Loudspeaker Cabinet components is a small loudspeaker called a ***Tweeter***. This is responsible for the high frequencies which gives us the freshness and clarity. Without hearing the Tweeter, a sound will be muffled. Tweeters are very directional and need to be aimed at the listener. As you move around to the side of a Loudspeaker Cabinet you will still be able to hear the Mid-range and Bass frequencies (they have a wider beam) but you won't be hearing the freshness and clarity, and the sound becomes muffled. For this reason, it is necessary to **tilt** a Loudspeaker Cabinet so that the Tweeter is firing at the centre of the intended zone of listeners. If a Loudspeaker Cabinet is just raised and not tilted forward, then the clarity and freshness will be fired off over people's heads.

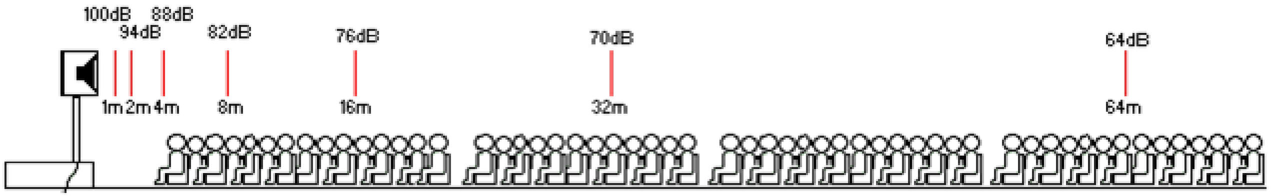
A NOTE ABOUT LIVE MUSICIANS AFFECTING THE SOUND. If there are Guitar or Electric Bass Loudspeaker Cabinets that have a lot of basses coming through them, then avoid placing them directly on hollow wooden floors or stages as the vibrations cause unwanted booming around the Church. A good solution is always place musician's Loudspeaker Cabinets on rubber pads, or spikes (blunt nails).
Placing an Electric Bass Loudspeaker Cabinet (that has a lot of basses) up close against a wall is a very bad idea. Basses expand and 'run' along walls causing excessive boom at the rear of the Church. You can always hear the effect of basses running along the walls by going to the rear of the room, listen to the sound and then lean up against a back wall; has the sound become really boomy and muddy? For this reason, it is best to keep all Loudspeakers away from floors or walls where the bass frequencies (long wavelength) can wrap around a room.

Loudspeaker Distance

1. Consider the Inverse Square law. It can help more of the congregation to listen at a similar volume:



If you double (x2) the distance away from a sound source, the volume will fall quadruple (x4) - *the 'Inverse Square' law*. The reason for this can be seen on the diagram: the energy at point 'B' is a quarter the energy at point 'A' because of the wider area it is spread across.
In sound engineering terms 'quadruple' or 'x4' means a change of 6dB of sound pressure level (SPL). **10x log (4) = 6dB.**



So, let's apply that:
In the above diagram we can see the volume falling as we move back from the Loudspeaker.
This example measures 100dB at 1 metre.
Using the Inverse Square Law, in the first 8 metres we lose 18dB (a lot). In the second 8 metre block we only lose 6dB.
After 16 metres the volume is much more constant all the way back.

So you can see that seating a group of people a little further back means they will all hear relatively the same volume (instead of blasting the front row a lot so the back row can hear a little).

2. Consider Critical Distance (Dc) beyond which any sound will be muddy and confused:

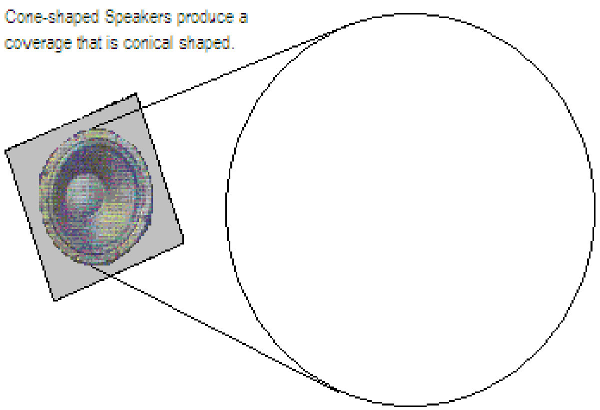
As you move back from a Loudspeaker Cabinet (indoors) you will hear increased reverberation. This happens as the sound reflects more and more off the walls.

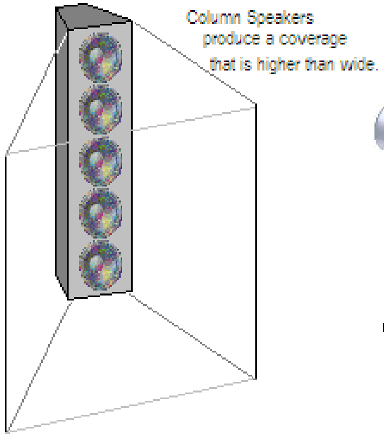
Continue moving back and you will eventually reach a certain point where the ***direct sound*** from the Loudspeakers is the same volume as the ***reverberated sound***. This point is the **Critical Distance** (Dc). The sound from here on back will be very muffled and acoustically unusable.

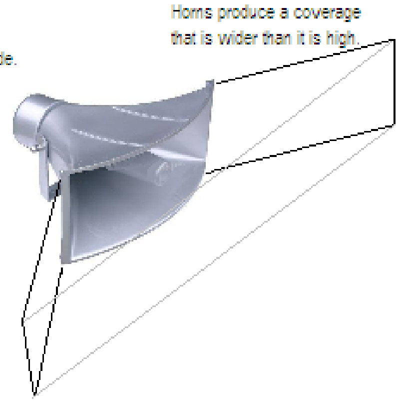
One of the signs is that the volume will not fall anymore from this point on back (it will be sustained by the ringing of the room).

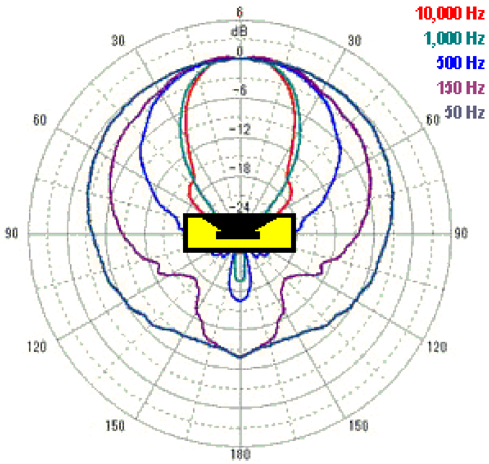
If there is seating in this area, then you need to set up a secondary Loudspeaker on a stand. This will give them direct sound and push the critical distance point further back.

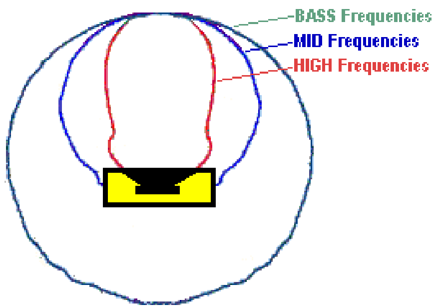
Consider how a Loudspeaker Radiates











If you stand directly in front of a Loudspeaker you will be able to hear everything that the speaker can reproduce. As you start to move around to the sides you will find a point where the high frequencies (fresh sound) has gone, and it is noticeably more muffled. As you continue to walk around to the rear of the loudspeaker you will notice that there are now only basses. If the cabinet was commercially made then the manufacturer will often supply a diagram showing how far around the high, mid and bass frequencies will wrap.

Every Loudspeaker Cabinet is quite unique, and it is a good idea to walk around a Loudspeaker Cabinet each time you use a new set. Listen for the point where the highs fall away. This is the limit of useful spread you can use. Now that you know the spread you can aim the cabinet so that all the listeners in your target area will hear a full sound.

Hanging Loudspeakers

Today Loudspeaker Cabinets are being constructed out of **synthetic** material rather then wood. This makes them a fraction of the weight.

Many cabinets are being designed now in a slight **wedge-shape** so that you can group them into an “**array**” and suspend them overhead.

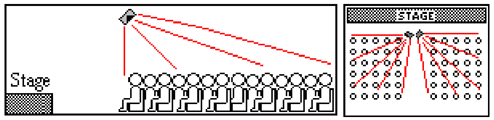
Sub-Woofers / Bass Bins

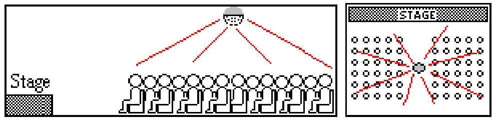
Normal Loudspeaker Cabinets, even big ones, are not able to give a really deep bass sound. In many situations a deep bass sound is not even desirable as it causes excess room rumble, however certain types of music do insist on having it. There are specially designed Loudspeaker Cabinets for this work which use labyrinth-style enclosures, which make them rumble. They are called **Bass Bins** or **Subs** and they contain large ***Woofer*** loudspeakers.
We normally mix everything together into one (mono) channel, filter out the high frequencies with a filter, and send the result to the Subs channel.

Bass frequencies disperse in all directions, so Subs can be placed on the floor or on the stage (they are usually too heavy to go on a stand). If the stage is hollow, then be careful because Subs can resonate the entire stage and cause an excess rumble. Subs placed close to a wall may also cause excessive basses in the room as bass frequencies run along any hard surfaces and walls. They require a lot of energy, typically more watts go to the Subs than go to the Front-of-House Speakers.

What is the effect of using Subs? Due to the fact that you filter out the mid-range and high frequencies in your Subs, and consequently filter out the bass frequencies in your regular Front-of-House, you will get a cleaner and seemingly louder sound out front because there are no really low frequencies taxing your regular woofers, and the Front-of-House Power Amps are not working as hard, plus there is more headroom.
Your Subwoofer Power Amplifier should have lots of ventilation or fan-cooling. As bass frequencies are non-directional you can “bridge” a Stereo Power Amp so that it is mono with much greater power (and is actually more efficient like this).
If you are using big wattage on your Subs be sure you are using heavy cable, and Speakon or Banana Connectors rather than ¼” Phone jacks.

Sound in ‘very reverberant’ Churches





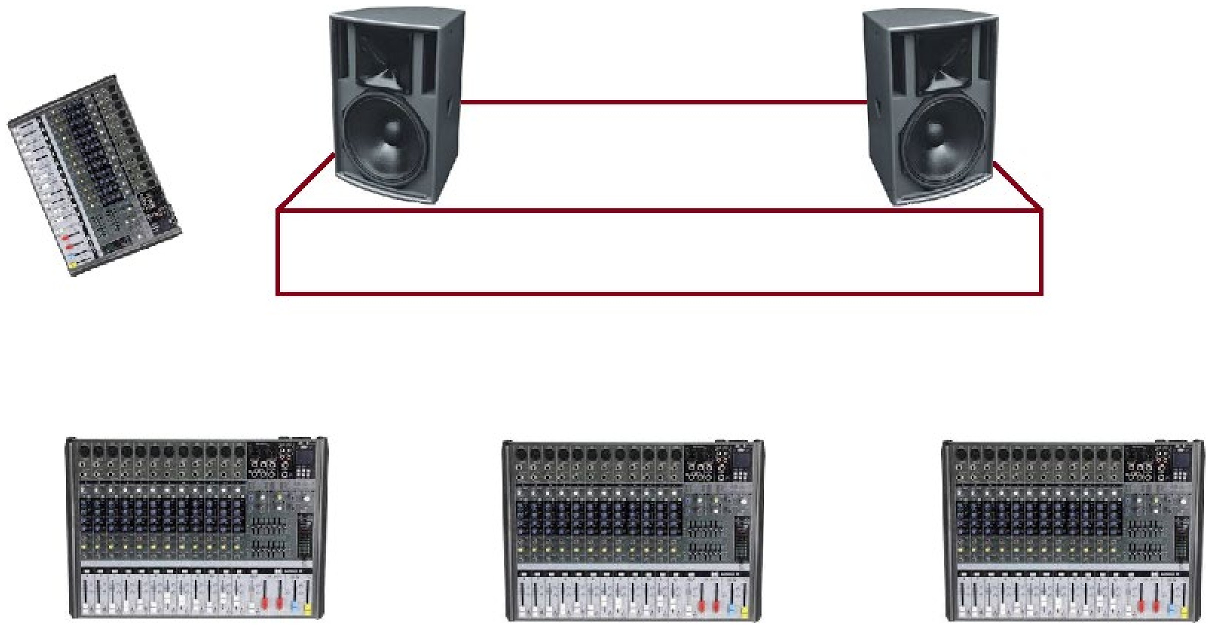
In large rectangular Churches everything will reverberate and boom if you use conventional Loudspeakers at one end of the building. The loudspeakers will cause the large mass of air to start rumbling, which will create a very short Critical Distance, beyond which point the sound will be muddy and confused.

Firstly, in a large rectangular church, the stage needs to be half way down the long side so that the congregation are all as close to the stage as they can be. This improves the *personal* experience of more people (there is nothing more impersonal than being down the back of a rumbling hall) and more people hear clearly.

Circular “over-head” clusters of speakers in the *centre* of large boomy venues will result in the same distance to all walls, and consequently the least amount of reverberation will be generated. This is far superior to loudspeakers down one end.

It is important to keep the volume down below the point where you start the room rumbling (you can hear the moment when a large room begins to rumble)… that is you volume limit, any louder and the people at the back will only hear mud.

Positioning the Audio Mixer



The person at the Audio Mixer (Sound desk) must regulate the mix so that it sounds balanced to everyone in the Church.

The mixer placed exactly in the middle of Left and Right Loudspeakers is not ideal as there are no Loudspeakers firing directly at them, and there is an acoustic hole in this centre zone.
The mixer at the rear is no good because there will be too much reverberation added by the venue walls, and the congregation will have absorbed too much.
The mixer on one side of the stage, beside the musicians, is impossible. The off-stage noise is too loud, and you have no way of knowing what the congregation are hearing.
The mixer in a separate room listening through a loudspeaker is absolute stupidity, you cannot know what the congregation are hearing because they aren’t sitting up close to a loudspeaker in a small environment, and their loudspeakers are not the same as yours, nor the same volume.

The mixer needs to be in the public area, halfway down the room, hearing what the congregation are hearing (obviously), directly facing a column of Loudspeakers so they can make the right choices.

Active Crossover

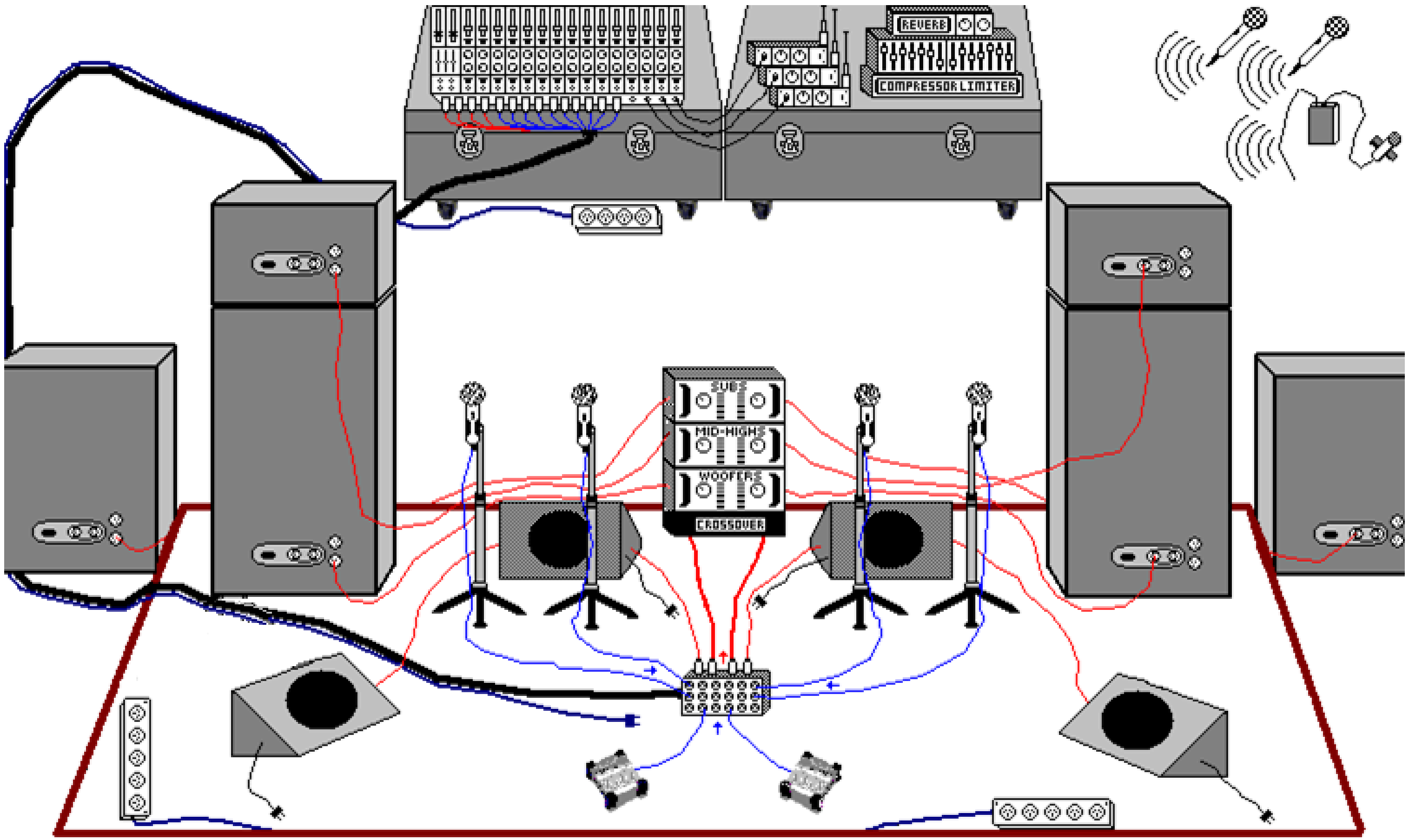
Very large Loudspeaker Cabinets will usually have no Crossover Filters inside them, nor will they have Power Amplifiers built-in. The cabinet just contain Loudspeaker cones.
In this situation you need to do the organise the crossover work yourself.
You connect the Mixer to an Active Crossover and program it to filter out all frequencies except the frequency zone you want to go to each particular Cabinet.

For example, you filter out the high and bass frequencies, and send this to the Mid loudspeaker cabinets,
You filter out the high and mid frequencies, and send this to the Woofer Cabinet.
You filter out everything except the super-bass frequencies and send this to the Subs (Sub-Woofers).

Distribution Line-Amplifier

With a large Sound System, if we just take the mix from the Mixer and connect it to a whole lot of Power Amplifiers (for the various Cabinets) there will be serious problems with the electronics because of impedance mis-matching.
A Distribution Amp is required. It has 1 or 2 inputs and many outputs. This allows a complex loudspeaker system to be connected with no risk of impedance mis-matching, and subsequent melting of circuit boards (quite expensive).

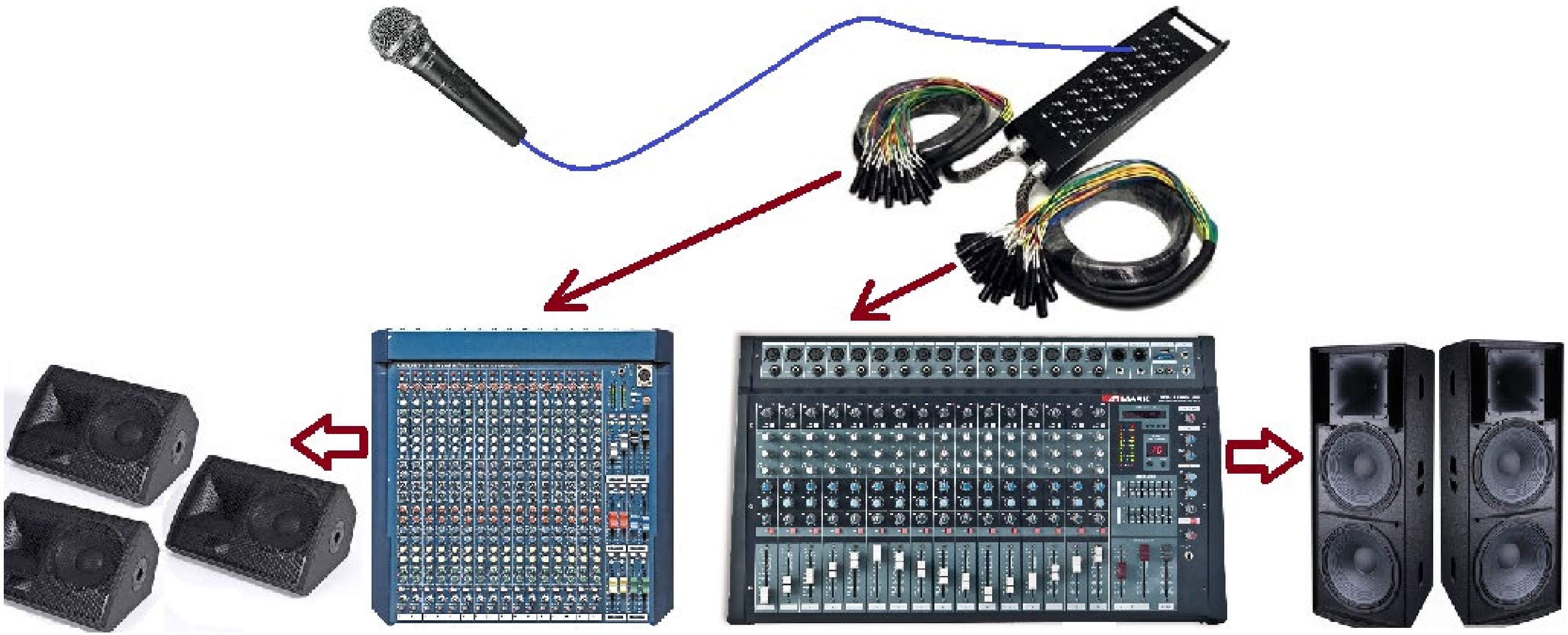
Example Configuration



In this example the Floor Monitors are active, but the Front-of House Monitors are passive (no power amps or crossovers inside).
The L-R mix from the Mixer arrives on stage at the Stage-box and goes in to an Active Crossover.
The Active Crossover is programmed to split off the frequency bands so that the lowest frequencies go to the Subs (Sub-Woofers), the basses go to the Woofers, and the mid-range to high frequencies are passed to the Mid-High loudspeakers.

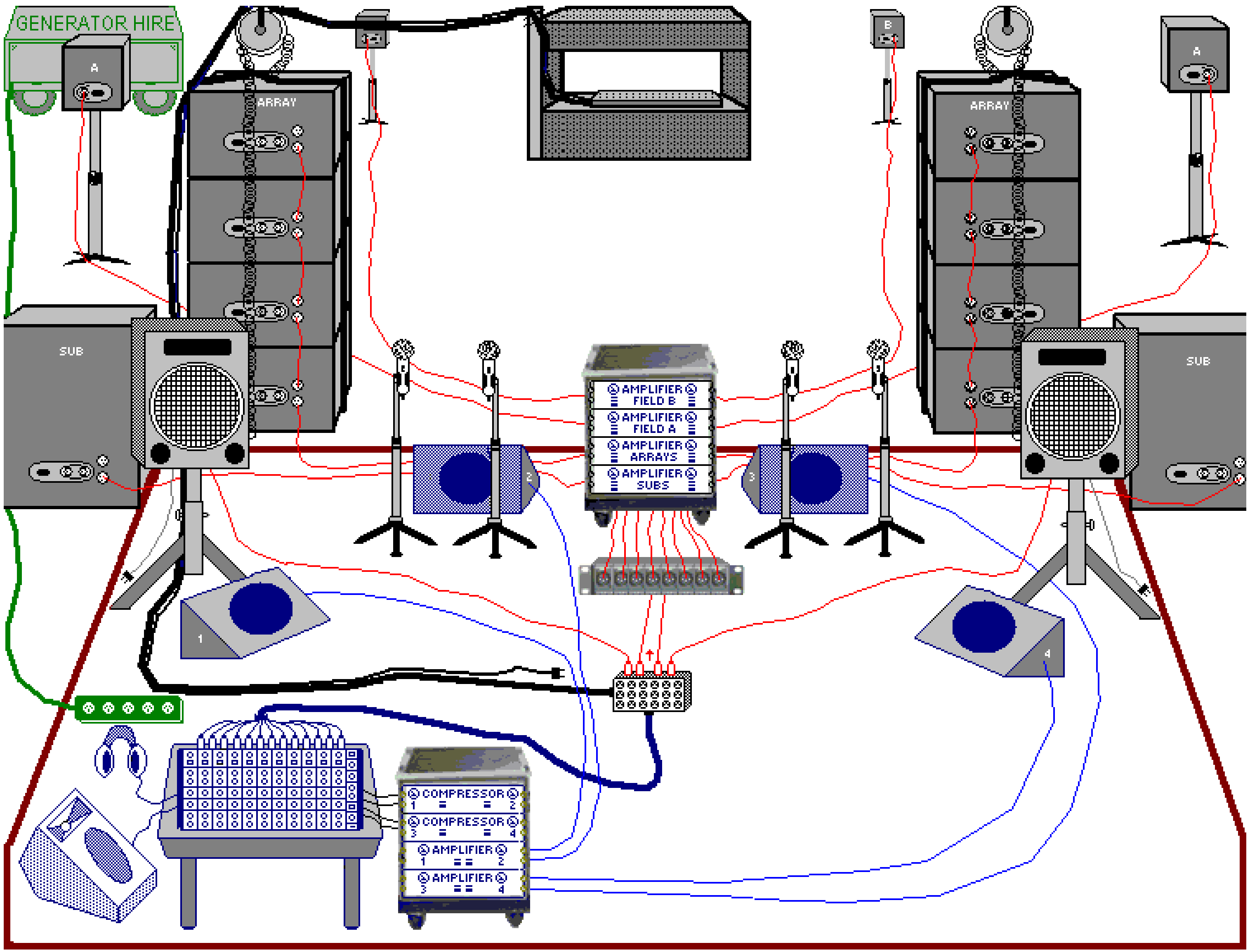
The Subs are placed on the ground beside the stage. The Woofers are on the stage, with the more 'directional' Mid-High loudspeakers placed on top (and will be angled down) so they can fire out to the congregation.

Side-Mixing the Floor Monitors



When you have multiple floor monitors, and the music teams are fussy about what they want in their monitors, then you can use a separate person with a separate mixer dedicated to mixing the floor monitors. To achieve this, we use a Stage box that has two multicore cables (snakes) instead of one. This is often called a **Split-Box**.
You connect the musicians and microphones into the Stage Box in the usual manner. Now connect one multi-core to the mixer for the Front-of-House mix, and connect one multi-core to the mixer for the Floor monitor mix. Musicians love **side-mixing** because they have the technician just off to the side ready to make any little adjustments they might require, and the person mixing the FOH always appreciates not having to think about the Floor monitor mix as well.

Once the music starts, there is always poor communication between the musicians and the sound technician. Who can imagine what those strange gestures mean when someone on stage suddenly tries to get the attention of the FOH technician. A separate floor monitor technician on the side of the stage is easy to whisper to, and is more in contact with what the musicians and singers are needing. There are even special Floor Monitor Mixers for this work. They come with a multitude of Aux sends, however you can use a normal mixer if it has sufficient Aux sends for you. Sometimes the technician who is doing the side-mix has a floor monitor of the same kind as the music team and quietly flicks switches to hear exactly what each performer is hearing (and what their problems might be).



Example Configuration

In this example the L-R Mix from the Mixer arrives at the Stage-box and goes directly in to a Distribution Box. This has 2 XLR inputs and 8 XLR outputs. The 8 outputs go in to the 8 inputs (L+R) on 4 Power Amplifiers.

The Loudspeaker Cabinets have their own Crossovers already built-in, so we just send all the frequencies everywhere and the built-in crossovers slice off the frequencies they don't want (no need for an Active Crossover).

Side Fills creating a "*Cross-Stage*" mix.

Particularly on wide stages where the music team are spread out and can't hear each other very well, we often place full range loudspeakers on the sides firing "across" the stage. The main purpose of these 'Side-Fill' speakers is for music team to be able to hear musicians on the other side of the stage.
As it would increase offstage noise, and greatly increase the chance of squealing everything, mixing cross-stage monitors must be done carefully.
Everything right of centre is mixed into the left side-fill only, and everything left of centre is sent to the right side-fill only. Lead vocals are mixed into both sides.
This results in a tighter sound-field on the stage, and the music team can hear each other just like they can on a narrow stage.

Never mix unnecessary things in the side-fills (if everyone can hear the drummer, or the electric guitar, then it shouldn't be in the side-fills).

Side-fills are usually placed on stands at head level. All performers say they hear much better with a side-fill.

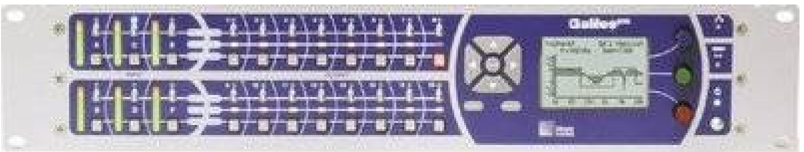
They are of particular value to worship leaders and singers who move about constantly.

Drive Rack Loudspeaker Management

You can purchase a device that connects to the output (L.R.) of your Mixer, which changes everything. Loud-speaker Management Processors, or Drive-Racks, have everything a serious sound technician could want.

Let's look at a dBx DRIVERACK® PA+ (for example):
It will ask you a couple of questions about your sound system, and then it will automatically equalise the whole setup. You connect a calibration microphone to it, and the internal Spectrum Analyser and Pink Noise generator will automatically send Pink Noise and then adjust the internal Graphic Equalisers accordingly. Now your Sound System will be completely linear, and not interfere with your sound. The Drive Rack will continuously run 12 Feedback Elimination Notch-filters on each channel. This will see any feedback squeals that might occur and pull them down. There is also a built-in Compressor, Limiter, Multi-band Parametric EQ, and Delay of very high quality on each channel.
Because it has a 2-Channel Input and 6-Channel Output (if you desire) it is an Active Crossover for you to send off to separate sub-woofers, woofers and mid-high range Amplifiers. There is a sub-harmonic synthesizer to give you a great Sub-Woofer sound. The USB connection to a computer allows you to control the box remotely, and also save your settings for another day.

As another example of a Drive Rack let's look at Behringer.
The ULTRADRIVE PRO DCX2496. 3IN and 6OUT.
It has all the above features of dbx including powerful computer editing software.

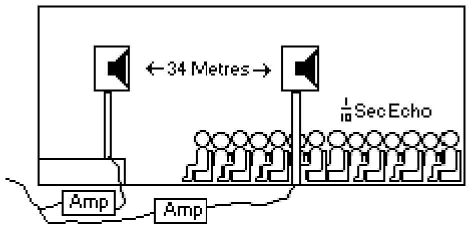


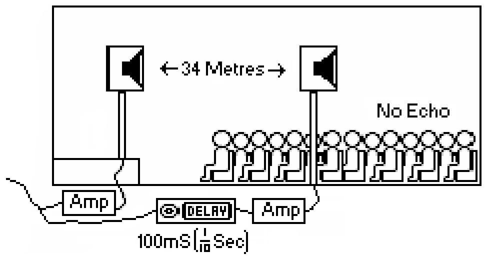
The company Meyer Sound offers the GALILEO 616. This is capable of 6IN and 16OUT.
It is very powerful when used with the Meyer Sound Array Speakers.

Loud-speaker Management Processors do a lot of work for us, better than we ever could.

Delaying Loudspeakers

In long Churches we need to add a second set of loudspeakers half-way along the building to compensate for the loss of volume that will occur, and to push back the “critical distance” rumble mentioned earlier. These secondary loudspeakers permit you to keep the front loudspeakers lower in volume (as you’re not trying to get your sound to reach the back row) which keeps the room rumble lower.



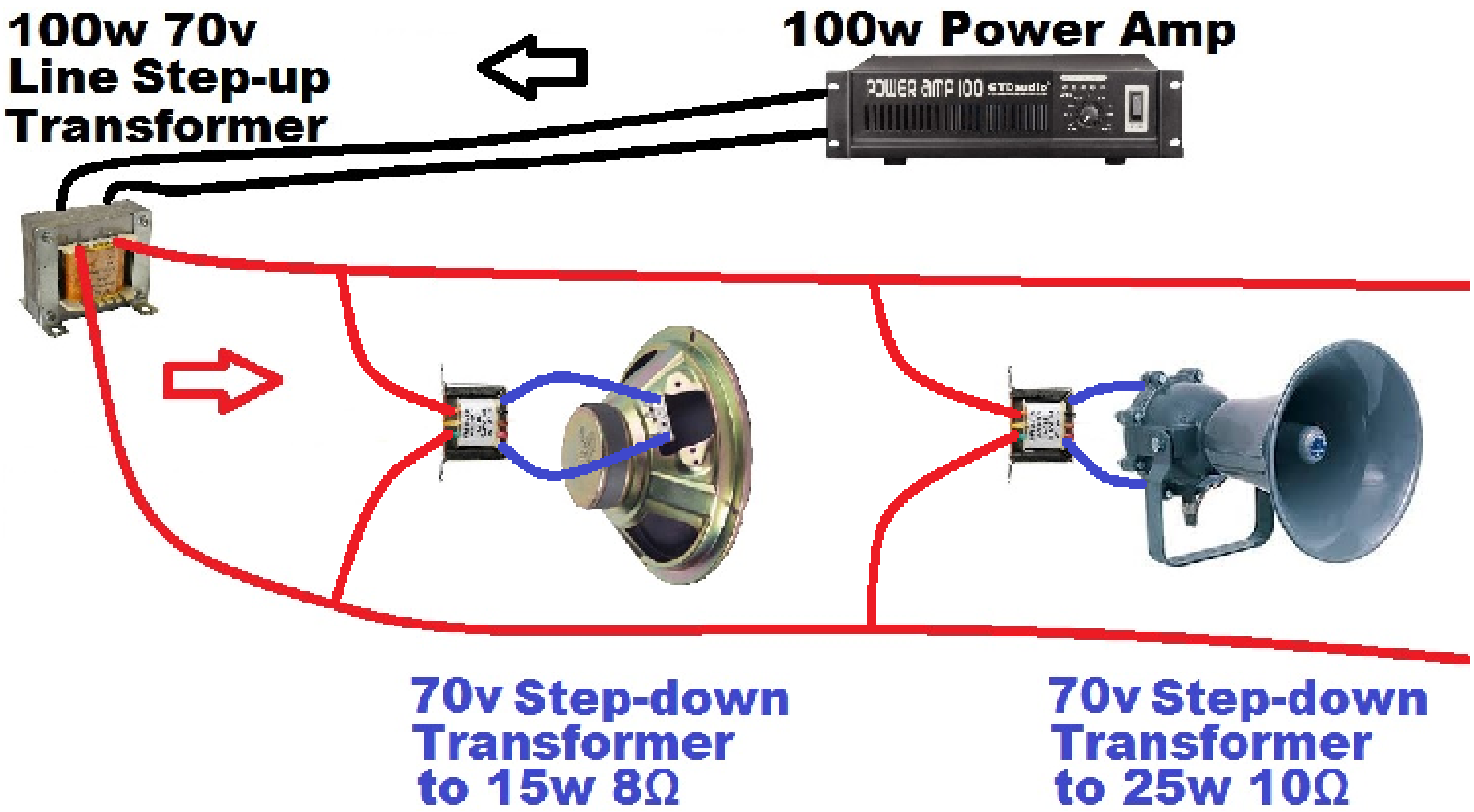


Sound travels through the air at approximately 343 metres/sec (1130 feet/sec). Sound will therefore travel 34 metres in 1/10 second (100mS).

Let us consider the left-hand diagram. Here the signal arrives at both Power Amplifiers (Front-of-House and Secondary Loudspeakers) at the same time.
The congregation at the rear of the room will hear the Secondary speakers immediately, and then they will hear the Front-of-House speakers (at a lower volume) 1/10 of a second later… after the Front-of-House sound has travelled 34 metres. This means the congregation seated at the rear will hear the same thing twice, and it will sound like an echo (or worse, a repetition).
In the right-hand diagram we delayed the signal we sent to the Secondary Loudspeaker Amplifier. Now the rear congregation will hear the Secondary speakers 1/10 second later, by this time the sound from the Front-of-House speakers has arrived as well. Both sounds will be in time with each other, so “no echo”.
We never need the Secondary Loudspeakers to be very loud as they only have to boost the volume that the Front-of-House speakers lost along the way.

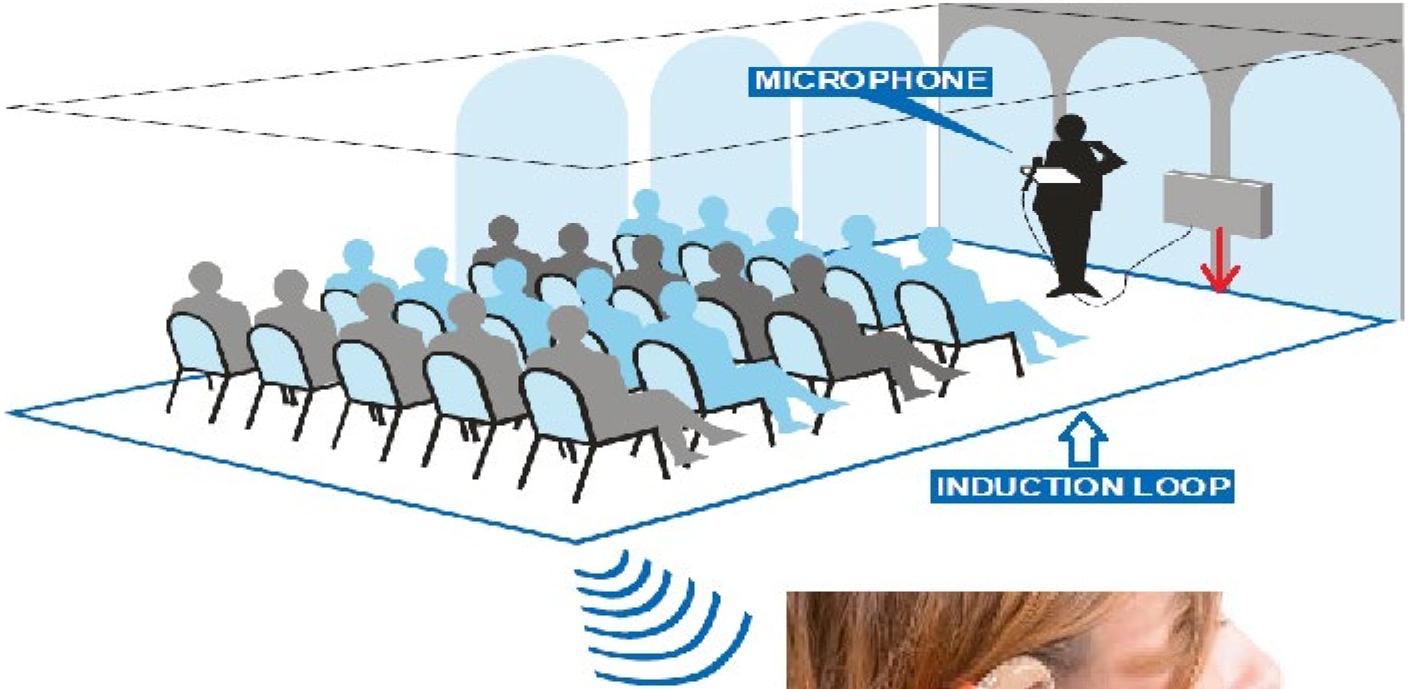
You can purchase Audio Delay Units easily, they are used for various purposes in audio and music. Guitar Delay Pedals will do fine in an emergency.
You can calculate the seconds of delay required by measuring the distance between the Front-of-House Speaker and the Secondary Speaker…
Metres / 343 = Seconds delay. If that looks too daunting for you, then just connect the Delay Unit and stand at the rear of the room. Get someone to talk on a microphone and adjust the Delay Time until you can no longer hear any echo.

Constant Line-voltage for long-distance Loudspeakers



If there is a situation where you would like to power extra loudspeakers that are a long way away (for example out in the foyer, or outside the building) you can use transformers to help you. This creates what we call a Constant Line-Voltage, and though it looks scary, it works very well. This is standard procedure in Seminar and Conference venues.

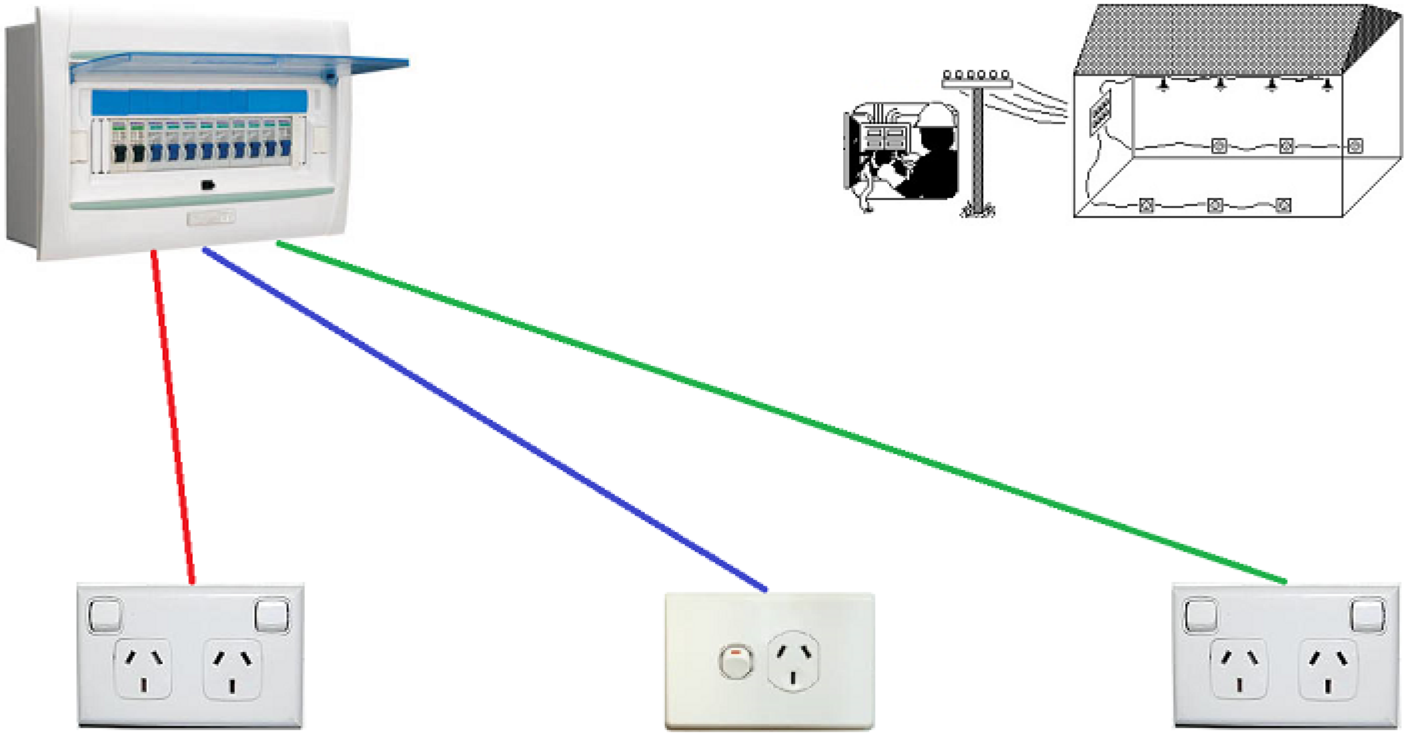
Hard-of-Hearing Induction Loops



One of the methods that exists to help the hard-of-hearing is to install a wire “Induction Loop” around the perimeter of a Church.
The wire Loop is connected to a Loop Driver, which is connected to the Sound system.

Our audio is sent through the loop, which creates a magnetic field.

Many modern Hearing Aids contain a Tele-coil (or T-coil) which picks up the magnetic field and converts it back to sound.
The advantage is that it will be a clean sound directly from the Sound System, without background noise, and the person doesn’t actually need to be able to hear the Loudspeaker.

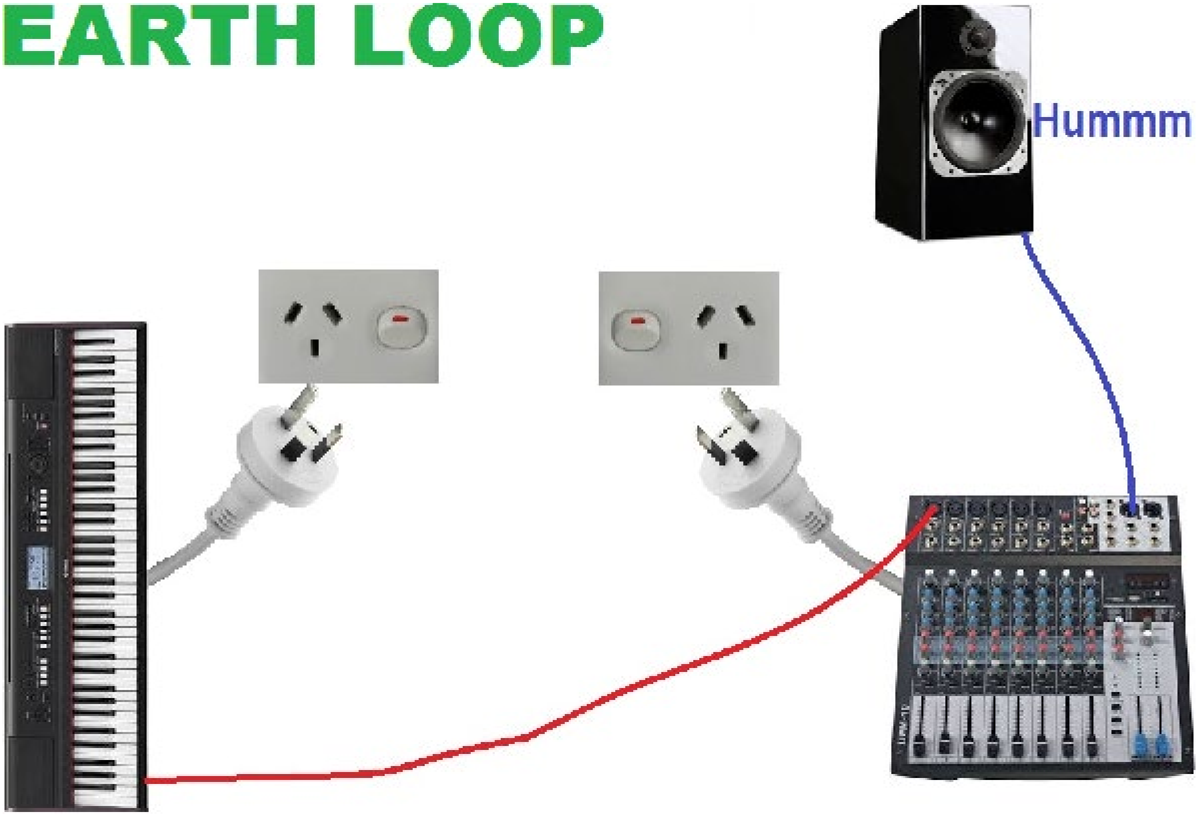


Powering a Sound System

Electricity comes from the Power Company, and connects to a building at the Switchboard.
Wall plugs and Light Switches are then wired in groups, and each group is connected to its own fuse at the Switchboard.

A Sound System should always be connected to the *same line* of power plugs.

EARTH LOOP



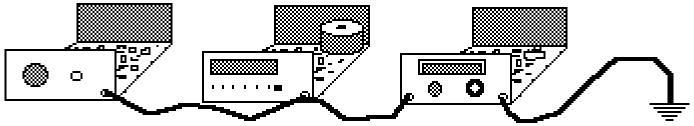
If the Stage area is plugged in to one Power plug group and the Mixer to another (eg. the back wall behind the mixer) there could be a clash in the AC (50Hz or 60Hz) frequency of the two lines.
When you connect the stage area to the mixer using a microphone cable or stage-box, you might immediately hear a strong 'hum'. This is called an Earth Loop.

To fix this, we run an extension power cable from the Stage area to the Mixer, so we know that all components in our Sound System are now powered from a single row of power plugs.

Still humming? Un-plug things one at a time until it goes away. It may not be an earth loop, it might be a cable with a broken earth wire.

Ground, or Earth, refers to a wire where zero volts are flowing. Audio signals rely on this neutral voltage as a reference point. Occasionally, for electronic reasons, the ground wire has a little current flowing in it. This will cause a hum. Careful earthing of all devices, and properly shielded cables, should keep electrical hum as low as possible.

Ground the Metal Chassis.



Use a thick wire and connect the metal cases (chassis) of all audio devices together, and on to a central grounding point. Although occasionally this can actually create a ground loop and make matters worse, it normally provides a low impedance path for any loop current, and stops it travelling down the cable shields. Some manufacturers put a screw at the back of their device to help you connect a wire and earth (ground) it.

Remember to use “balanced’ cables wherever possible

Balanced 3-pin (usually identifiable as XLR connectors) and un-balanced 2-pin (usually identifiable as RCA and Phone).

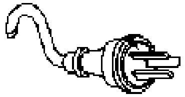
Always prefer cables with the XLR option whenever you have the choice. Phone and RCA type cables are subject to picking up hums and radio interference which will mix in with your audio. Although it isn’t very practical, the ideal would probably be to never connect a Phone or RCA cable directly to a Mixer because even one unbalanced circuit in a balanced system unbalances the whole, leaving the system open to interference.

Keep unbalanced cables short because the longer an unbalanced cable gets the more efficient it is at picking up RFI (radio frequency interference).

A note about disconnecting the earth screen (shield) on the audio cable

Occasionally, for various reasons, a 3-pin balanced microphone cable could pick up background noise. One solution technicians use is to disconnect the shield (wire screen) on one of the two ends of the cable so that the low frequency parasite current cant flow along the screen. Unfortunately, a one-end-only shield connection increases the possibility of high frequency (radio) interference because the cable now resembles an antenna. A small capacitor (0.1 or 0.01 microfarad ceramic disc) connected from the lifted end of the shield to the chassis will eliminate these Radio Frequencies, especially with the increasing use of digital and wireless technology greatly increasing the possibility of RF noise.

Removal of the (third) ground pin on the Power plug



Occasionally the third pin on a power plug can be involved in establishing a ground loop. You can tell this is happening because using a two-prong adapter makes the hum go away. Some technicians just cut off the third pin with some cutters. If you choose this measure, then you must realise that your equipment now has no electrical power ground and you increase the ***risk of electric shock*** to you or someone else. If you choose to use a two-prong adapter, or cut off the pin, then consider running a wire from the chassis to a good earth somewhere (ideally a metal rod in the ground). Most technicians avoid this whole approach.

CREDITS

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Text: *Original, by the Author, a Christian Recording Engineer.*
Images: *Designed by the Author. Some photographs were sourced from the Internet, then re-worked.*

Ever since the creation of the world, God's invisible attributes and divine nature have been evident. They are clearly understood through his workmanship, and all the wonderful things that he has made. Therefore, those who fail to believe and trust in him are without excuse, or defence. **Romans 1:20**

All of us have sinned and fallen short of God's glory, but God treats us much better than we deserve.
Because of Christ Jesus, he freely accepts us and sets us free from our sins. God sent Christ to be our sacrifice. Christ offered his life's blood, so that by faith in him we could come to God. **Romans 3:23**

If you declare with your mouth, "Jesus is lord," and believe in your heart that God raised him from the dead, you will be saved. For it is with your heart that you believe and are justified, and it is with your mouth that you profess your faith and are saved. **Romans 10:9**

For the Scripture (*Isaiah 28:16*) says, "Whoever believes in Him will not be disappointed." **Romans 10:11**

These things have been written so that you may believe that Jesus is the Christ, the son of God; and that by believing, and relying on him, you may have new life in his name. **John 20:31**