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Live Sound Engineering

ROCK-tech Training Series

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Training Day Contents

A brief introduction to live sound in church

Overview of a PA system and our role

Microphones, ‘how to’ and feedback

D.I. boxes, signal types, hums and buzzes

- break for lunch -

Understanding the basics of sound

Mixing console overview, EQ and ‘an approach to mixing’

Questions and answers

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A brief introduction to live sound

- What does PA stand for?
- Do I really need one?
  - i.e. small group

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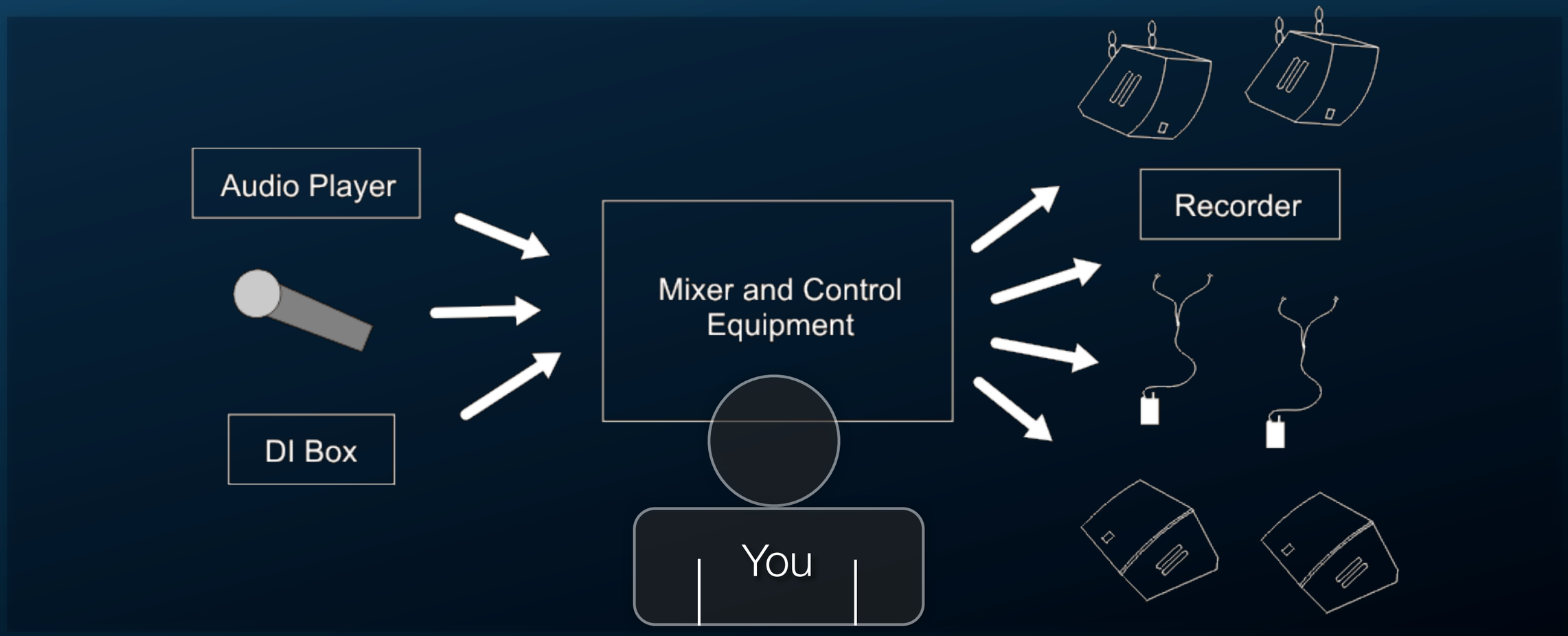

What are the core elements of a PA system?

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What is a church sound engineer's job description?

- Take 'raw' audio sources from various places, adjust and mix them together and send to the audience(s).
- Not a 'sit-behind-a-desk' operator.
  - Need to get out amongst the audience and onto the stage.
- A servant

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Who are we serving?

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What do they need?

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any other technical job anywhere in the church :)

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Let's look at:

Sources

- Microphones
- Feedback
- DI boxes
- Signal Types and Hums & Buzzes

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Microphone Types

- Dynamic
- Condenser/Capacitor
- Ribbon
- Piezo Transducer / Pickups

Dynamic Microphones

- The incoming sound waves move a diaphragm, which is attached to a coil of wire, around a magnet. The movement of the coil through the magnetic field creates an electrical signal in the coil.
- Generates a small amount of output level
- Simple and robust
- Passive - doesn’t require any power
- Limited transient and frequency response

Condenser/Capacitor Microphones

- Measures capacitive charge between two plates.
- Very small output level, so typically house an internal pre-amplifier, resulting in a moderate output level.
- Fragile and sensitive
- Requires power
- Excellent transient and frequency response

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Ribbon

- Natural sound
- Very fragile
- Quite expensive
- Awkward to use for a live event

Piezo Transducer / Pickups

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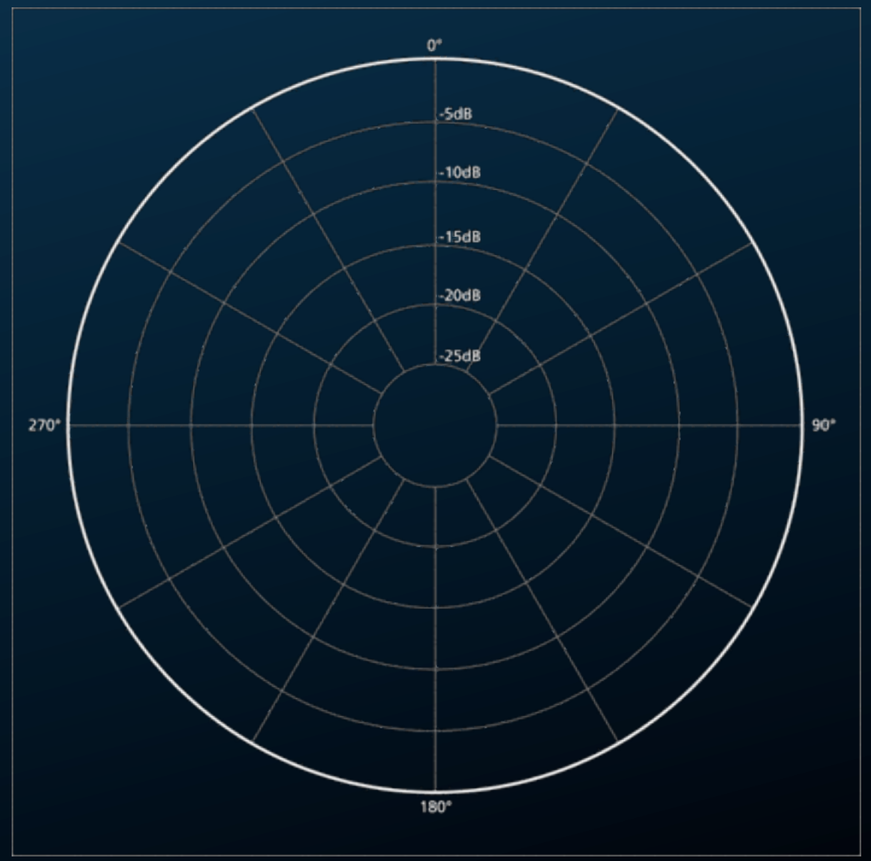
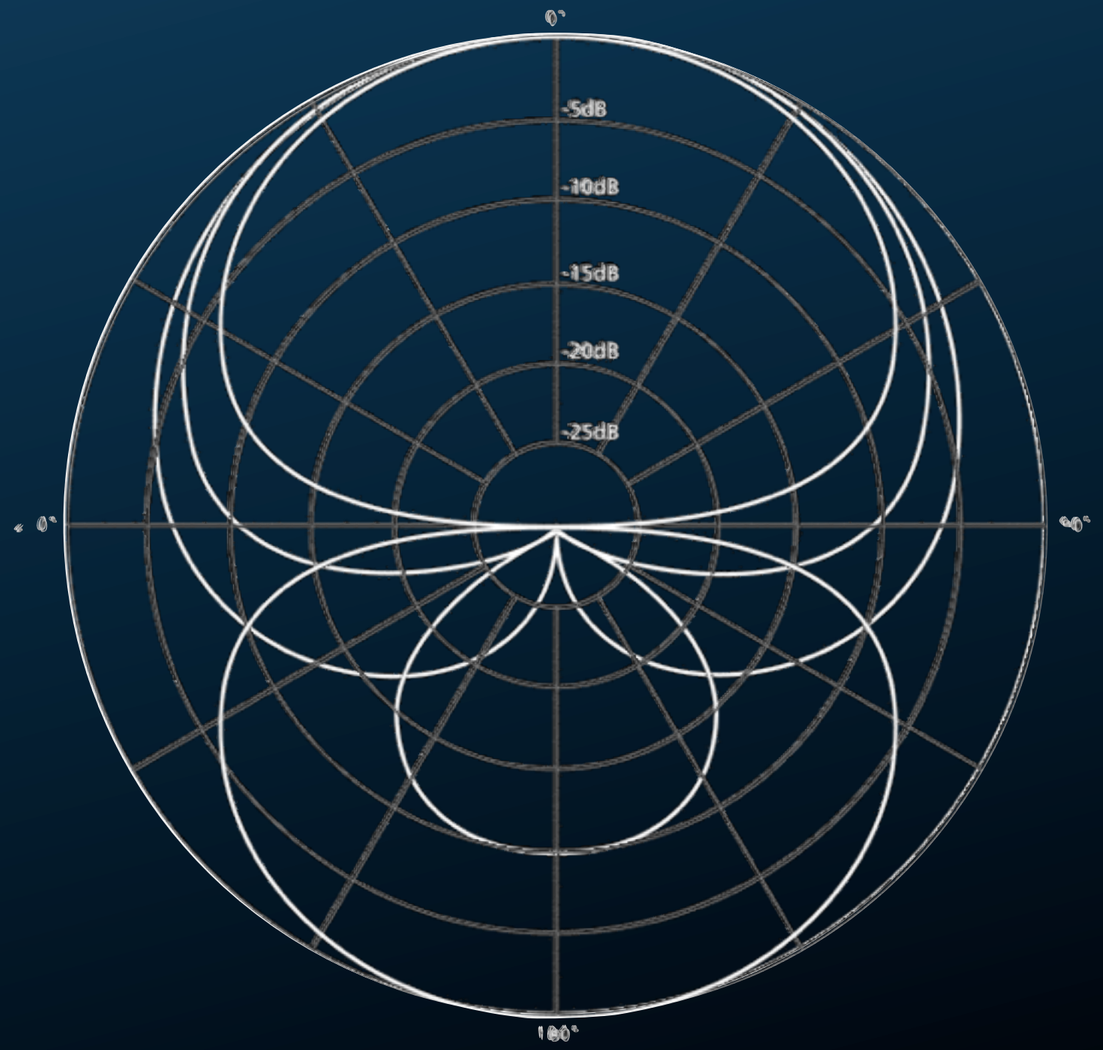
- Designed to capture sound through vibration or a magnetic field - *not movement of air*
- *Piezo* - Vulnerable to shock/impact noise
- *Pickups* - Vulnerable to hearing aid loops or sources of electromagnetic radiation

Microphone Directionality

- Omni-directional
- Cardioid
- Hyper Cardioid
- Figure of Eight



Differences Between Polar Patterns



Instrument and Vocal Microphones

- Vocal Microphones:
  - Built in pop shield
  - Reduced handling noise
  - Tailored frequency response, optimised for the human voice
- Instrument Microphones:
  - Generally flat frequency response (or a specific response for a certain instrument i.e. Sennheiser e901 for the kick drum)
  - Tailored maximum sound pressure level. Some can handle loud sources, where others are very sensitive to quiet ones.

What is Feedback?

What is Feedback?

- Feedback is caused by sound waves traveling in a loop through an amplifying system.
- Typically this would be in a speaker-microphone loop. For example: the sound travels out of a speaker into a microphone, back through the PA and then back out of the same speaker again (this time louder!), back into the mic, and so on, round and round.
- Each time the sound travels around the loop it gets louder, and louder and can be heard as a loud ‘squeal’, ‘ring’ or ‘rumble’ through the speakers.

What is Feedback?

- In a typical acoustic-feedback-loop one frequency has less attenuation than the others. So the feedback is at a specific tone rather than across the whole frequency range.
- It could also be through a recording system on a computer, an FX unit, or a hearing aid loop into a guitar amplifier!
- Eventually the sound will get so loud that one of the devices in the loop will start to clip and overload. This will act a bit like a limiter and stop the sound getting any louder.

Removing Feedback

- To remove a feedback loop you have to increase the attenuation in the loop until it is greater than the gain of the system, or reduce the gain of the system.
- Ways of introducing attenuation into a feedback loop:
  - PHYSICAL
    - Point the microphone away from the speaker (or vice-versa).
    - Use a different microphone (with a more appropriate polar pattern)
    - Change the acoustics of the space and add time delay.
    - Move the microphone away from the speaker
  - ELECTRONIC
    - Turn down the volume of the microphone.
    - Listen to the feedback 'tone' and adjust the microphone channel EQ (or a graphic or a narrow band parametric) to turn down those specific frequencies. (typically, limit yourself to attenuating three frequencies!)
    - Pan the sound to a speaker which is further away from the microphone.
    - Remove any 'auto' gain controls, such as a compressor.
    - Add in 'auto' attenuation controls, such as a gate.
    - Add a small amount of time delay to the signal (~5ms, this can help occasionally).

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What does DI box stand for?

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Active or Passive, DI?

Active	Passive
Require power (phantom is best)	No power needed
High bandwidth	Low bandwith
Clip when overloaded	Saturate when overloaded
No loss of signal strength	Small loss of signal strength
Kinder to the source	More demanding of the source

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DI Boxes can do **four** things...

...what are they?

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Adjust the input sound level...

...Why?

Pad / Attenuation Switch

- Distortion / Clipping

  or

- Hiss and Noise

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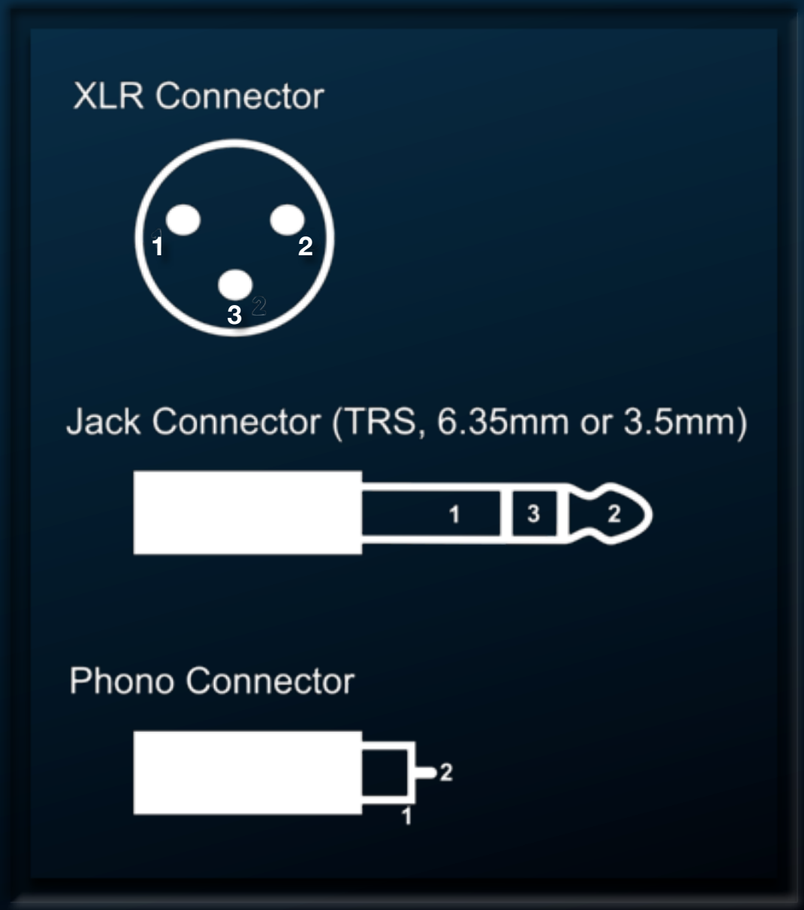
Convert an unbalanced signal to a balanced signal...

...Why & what signal types are there?

Balanced and Unbalanced

- An unbalanced signal is susceptible to interference, hum and buzz, especially over longer distances.
- A balanced line utilises a ‘noise canceling’ inverted signal that is run alongside the main signal.
- At the mic pre-amp the signal is derived from the difference between the two versions of the signal (+/-), which removes unwanted noise picked up along the way.
- The ability of the preamp to do this is called the Common Mode Rejection Ratio of the microphone preamp (CMMR).



Signal Transmission

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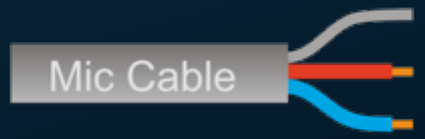
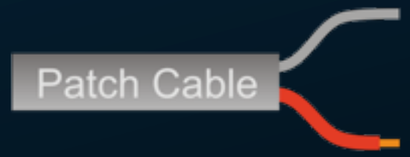
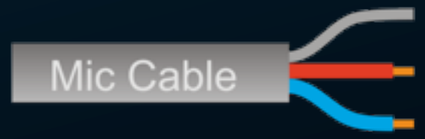
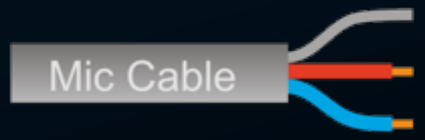
Type	Cable	Note	XLR	Jack
Balanced		**Ground**	1	1
		Hot +	2	2
		Cold -	3	3
Unbalanced		**Ground**	1	1
		Hot +	2	2
Stereo		**Ground**		1
		Left +		2
		Right +		3
Insert		**Ground**		1
		Send +		2
		Return +		3

Balanced / Stereo Demonstration

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Signal Types

- Microphone Level (balanced and unbalanced)
- Line Level (insert, mono and stereo)
- AES/EBU Digital
- Speaker Level
- DMX
- Remote Controls (i.e. smoke machine)
- Comms Belt-packs
- RIAA EQ - record deck
- Chinese Motorbike Mains Charger!

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It splits the input signal...

...Why?

Split the signal

- Example of a Bass Guitar and Bass Amp

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What is the earth / lift switch for?

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Ground and Earth ‘Lift’

- NEVER remove the earth pin/wire from a mains power cable
- Try to have only one source of ‘ground’ to each device
- Avoid loops where ever possible
- Stereo devices often need one lift / one ground
- Remember the example of a mains powered stereo keyboard, plugged into a stage box
- Use extension leads to create a ‘star’ style power distribution network

Direct Injection (DI) Boxes Summary

- 2 Types:
  - Active
  - Passive
- 4 Main Uses:
  - Used to convert from one signal type to another
  - Can be used to ‘break’ earth loops (a cause of hum & buzz)
  - Splits the signal. i.e. Bass guitar split to: FoH Desk and Bass Amp
  - Attenuates the signal, to avoid clipping and distortion

DI Boxes - Things to be careful of:

- Active DIs can be ‘clipped’
- Don’t use batteries in an active DI box, they run out when you least expect it.
- Cheap Passive DIs have a limited frequency response
- Cheap Active DIs are noisy and clip easily
- Accidentally switched PAD attenuators can cause extra noise.

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Lunch Time!

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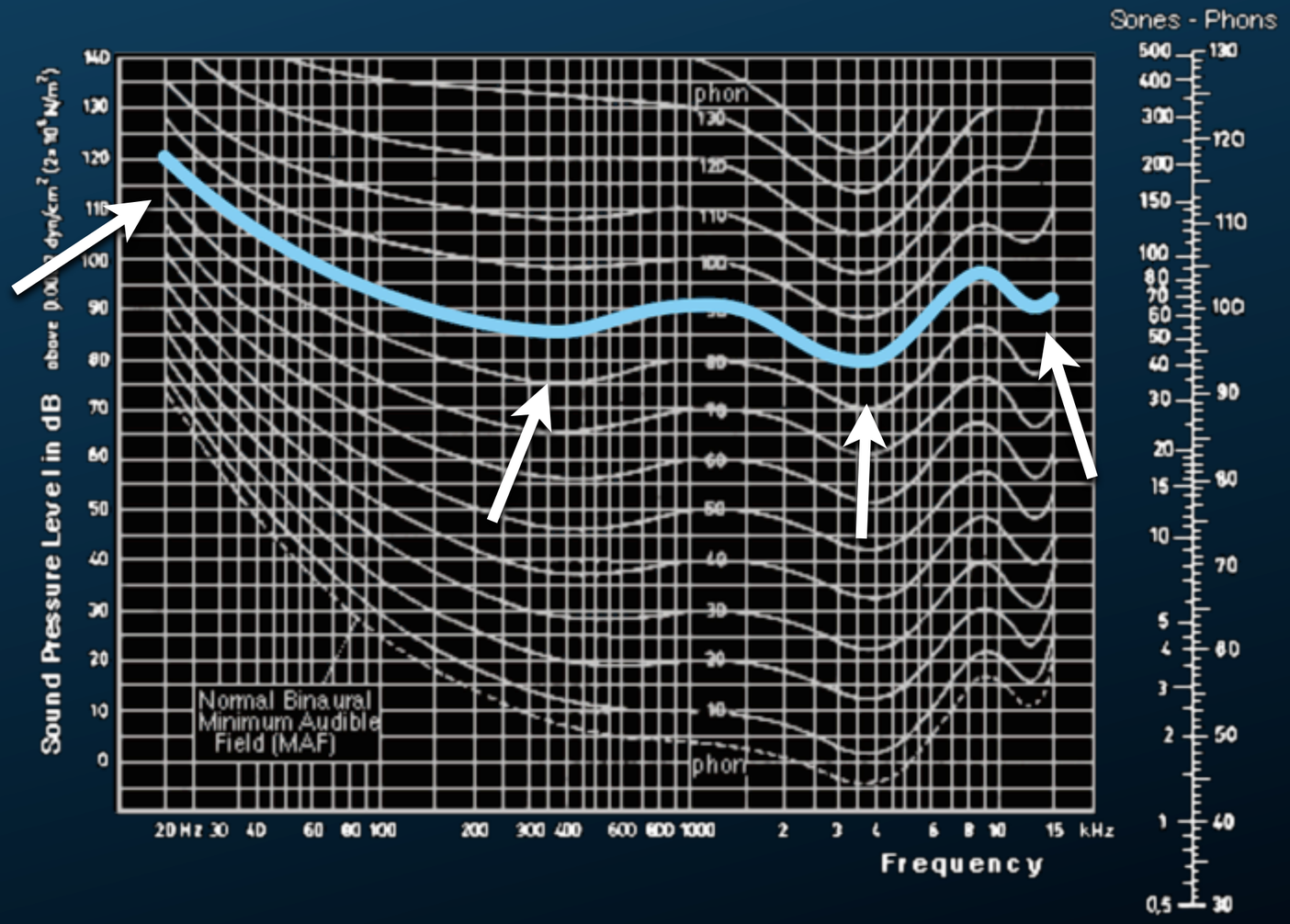
Sound and a simple insight into how it works

- Ear Technology
- Frequencies
- 8 Vocal Sounds
- Developing a ‘Head Sound’
- Test Tones Game!



Phon Scale - Hearing Sensitivity

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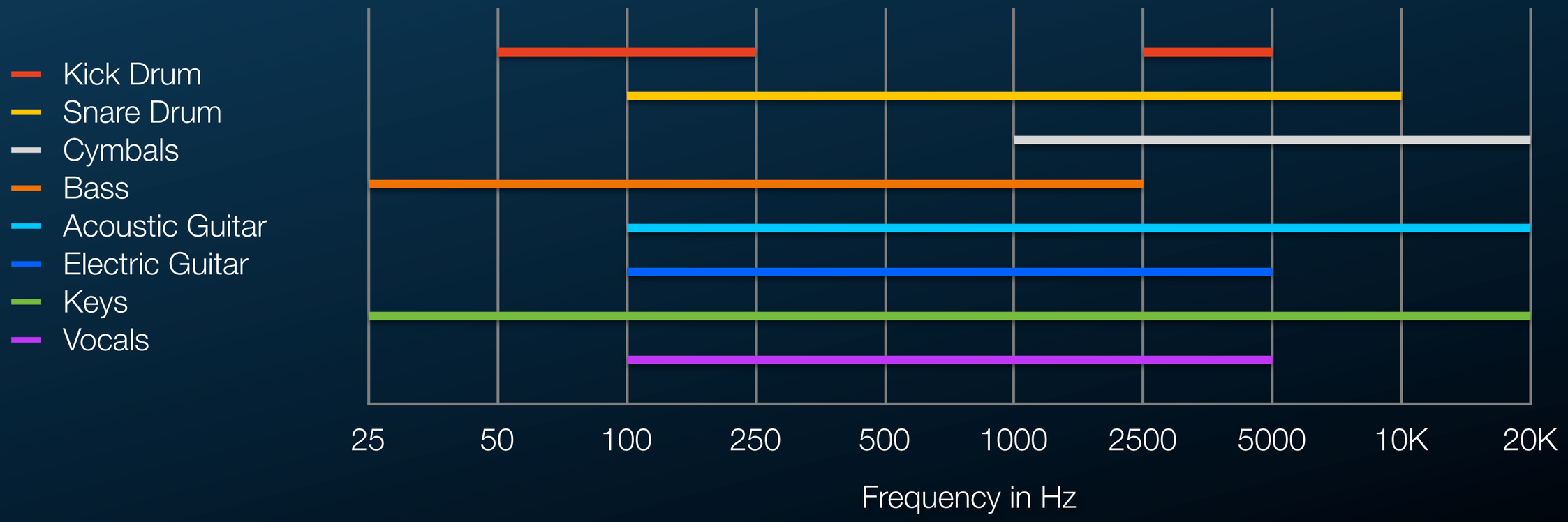
Typical Frequencies of Instruments



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Learn the 8 vocal sounds and their frequencies

Vocal Sound	too low	hmm	werr	orr	eee	shh	sss	to high
Frequency Hz	50	100	300	750	1,500	3,500	6,000	10,000

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Divide the frequency spectrum into **eight sections**

Choose a **section for each** part of the band

iPhone App

- There is a great little iPhone App called Quiztones.
- It’s quite good to practice training your ear when you’re bored!

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Mixing consoles and “An Approach to Mixing”

- Gain Structure
- Tone and Equalisation
- Signal routing: subgroups, auxiliaries, matrix etc...
- An Approach to Mixing

Signal Routing

- Auxiliary Outputs (Pre, Post)
- Groups
- VCA / DCA
- Matrix Outputs
- Direct Outputs

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Bass / Electric Guitar

Kick / Snare

Vox / Band

Mix Examples

Good ideas to help you mix

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- Develop your own '**Head Sound**'
  - Know what you want it to sound like
- Make a **Hole**, not a **Boost**!
  - Make space for each bit of the band using the EQ
- **Divide the frequency spectrum** into 8 sections
  - Pick a favourite instrument/vocal for each section
- Learn the **8 vocal sounds** and their frequencies
  - to low, hmm, werr, orr, eee, shh, sss, to high!
- **Don't believe your writing** on the channel strip!
  - Use EQ to remove unwanted noises from channels

Amplifiers and Speaker Systems

- Gain structure
- Impedance
- Cable losses
- Is there more to life than frequency response?
  - Directionality and Coverage
  - Phase
  - Steady State versus Transient
  - Compression (Thermal and Power)
  - Sound Pressure Level (SPL) - dBs, crest factor, ‘peak’, measurement, Leq.
  - Damping Factor

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Directionality, coverage and speaker-space relationships

- Typical Setup and the problems encountered...

- Reflection, Diffusion and Absorption - Room Acoustics
- Time Alignment
- Phase
- Feedback

Recording

- Clipping - distortion will occur if you overload the input
- Bit Depth - distortion will occur if you underload the input
- Noise - noise & hiss is very obvious
- Multi Channel, Mono or Stereo
- Compression & Automatic Gain Control (AGC)
- Ambient Microphones - Help to create atmosphere

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Radio Systems

- Wired v Digital Radio v Analogue Radio
- Losses and Distortions
  - Dynamic Range (compounder)
  - Frequency Response
  - Noise and ‘Artifacts’
  - Clipping and Distortion
- Frequencies, Intermodulation, Bandwidth and Squelch
- Tools to help
- Licensing

Monitoring

- Foldback or Monitor Wedge
  - Acoustic Spill
  - Feedback
- In Ear Systems (Radio & Wired)
  - Isolated
  - Operator Skill
  - Maintenance (batteries etc.)
- Personal Monitoring Systems - ME1

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Understanding Basic Effects

- Pre or Post? - How to connect them
- Reverb
  - Simulating a room
  - Early Reflections
  - Decay time
  - Gated
  - EQ - average room ‘sound’ and HF attenuation
- Delay
  - Tap Tempo
  - Feedback

Dynamic Controls

- Two main types:
  - ‘Functional’
  - ‘Musical’
- Have many hidden side effects (i.e. increasing feedback with a compressor)
- Can easily make things worse not better
- Require continual adjustment
- Non-essential

Dynamic Controls

- ‘Musical’
  - Compressors / Limiters
    - Turns loud sounds down (by a ratio) - i.e. Lead Vocal
  - Expanders
    - Turns quiet sounds down (by a ratio) - i.e. Radio Mic Noise
- ‘Functional’
  - Duckers
    - Turns loud sounds down (by a fixed amount) - i.e. Voice Over, Auto Mix
  - Gates
    - Turns quiet sounds down (by a fixed amount) - i.e. Drum Spill

Dynamic Controls

- Adjustment Parameters
  - Threshold - *when it starts working*
  - Ratio (musical) or Range (functional)
  - Attack - *suppress (0-2mS) or enhance (5-50mS) transients*
  - Release - *smooth or sudden change back to normal*
  - Gain - *to bring the <u>average</u> sound level to the same as before*
  - Side-chain - *Frequency Range and Source*

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Hints when sound checking

- Ask the musicians to play. - Don't forget your 'please' and 'thank you's!
- Balance stage noise/spill for the front row
- Optimise Gain at FoH
- Identify any problems on each channel
- Adjust EQ to optimise sound
- Visit stage and discuss monitors and optimise until the band are happy
- Back to FoH, bring in lead channel (often lead vocal), and set overall volume level.
- Gradually introduce instruments (drums, bass, guitars, keys, backing vocals etc.). Creating holes and space in each one to allow the others to fit.
- Keep going until happy! Don't forget to revisit the stage to check how the band are doing.
- Also remember to walk around the room and listen amongst the congregation so you know what it'll be like for them.
- Remember that people absorb sound well, so a room will typically get about 3dB quieter when it's full. Will your headset/tie mics have a enough level to be heard with this extra absorption?
- If you have a problem, try and sort it out at the source (move mics, earth lift DI etc.) before you 'fix' it at the desk.

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Sound for Video, Location Recording and Church News

Step 1. - The Right Equipment

Step 2. - Record the Audio Well

Step 3. - Edit the Audio

Step 4. - Mix the Audio

Step 1. - The Right Equipment

- A SECOND PERSON
- A tie mic for each person talking in an interview style (cables are often fine).
- A handheld microphone for ‘walk about’ interview style.
- A directional boom microphone to capture a more ambient sound to add to the mix.
- Small compact mixer - Rolls Battery Mixer or A&H Zed10.
- Closed back sound isolating headphones.
- A stereo recorder (4 track is even better). If your camera has an audio input then you can use that as a stereo recorder to save re-aligning the audio later. Make sure you can plug your headphones in to listen to what you are recording. The Zoom H4 is a good cost effective choice, or a laptop with a decent sound card.

Step 2. - Record The Audio Well

Listen

- Check for background noises (passing traffic, noisy fans, heaters etc.) Shut your eyes and listen! Also listen on closed back headphones.

The right mic in the right place

- Use a combination of tie mics and boom mics for the best result. Try to only use 1 mic per sound source.
- Make sure tie mics won't rustle against any loose hair or clothing.
- Are you using the right microphone? Check your microphone positioning. Is it pointing away from noise and towards the source?
- Check the reflective acoustics of the space that you are in. i.e. an omnidirectional microphone near a glass window will sound odd.

Switch off auto gain - noise/clipping

- Do some trial recording to check the input level. Too loud and it will clip, too quiet and it will be noisy.
- Make sure someone is listening to the sound on good sealed headphones whilst you're recording the video! Make a note of any issues as you go.

Step 3. - Edit the Audio

- Import the audio into your editor, and quickly listen through everything. Note any clicks, bangs, noises etc. that you want to remove.
- Carefully go through each track and carry out the editing work.
- Headphones are often best for this.

Step 4. - Mix the Audio Pt 1.

- Firstly find out where this audio will be listened to, and try to recreate that situation as best as possible.
- For example if it's church news and going to be played over the PA system, then do the **mix down through the main PA**, and check to make sure it's ok at the final volume level. You will be surprised at the difference in sound, in comparison to a pair of small computer speakers!
- Be ruthless with **removing unwanted frequency content** through EQ. (HPF, notch filters, etc.)
- Apply compression, noise reduction and de-essing sparingly. Remember many of these dynamic processes will **improve some aspects** but make **others worse**.
- Try and **come back to the recording later on** and have a fresh listen, it might help keep it balanced.

Step 4. - Mix the Audio Pt 2.

- Have a top quality reference recording to match and compare your sound with. A BBC nature documentary, or perhaps a good news program for example.
- Use Volume AND Eq to create space in audio tracks when overlaying music and spoken voice. Try a 4.5dB cut at 3KHz as a starting point.
- Make sure you lip sync the audio to the video with headphones, to ensure the most accurate results. Most digital desks can delay the channel audio to align it with any future delay in the live video system.

How to Deal with a Loud Drum Kit

- This is a common problem faced by many churches
- Core Issues:
  - Loud **snare drum** and **cymbals** heard on the front and rear rows.
  - Spill into mics on stage (especially for quiet sources i.e. flute, violin, vocals)
  - Spill into other musicians ears.
- To Solve the problem requires:
  - **Diplomacy** - *discuss the situation with the drummer. Remind them that it's the cymbals that are hard to deal with.*
  - **Acoustic Treatment** - *absorb as much reflected sound as you can - above, behind and to the side of the drummer.*
  - **Good Mic Choice and Placement** - *try to position and point sensitive mics away from the kit.*
- Extra 'helpers': Zildjan Gen16 AE Cymbals

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Any Questions?