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Studio Production and Directing

Sound - Acoustics and Microphones

Vladimir Maksimovic

University of Mitrovica (UPKM)

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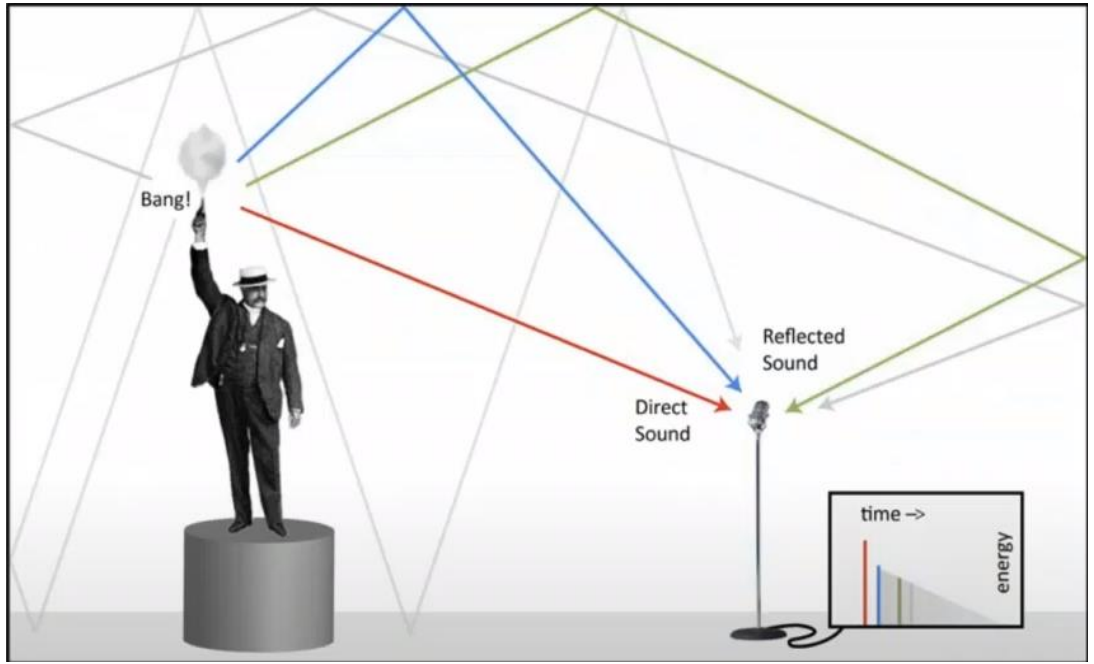
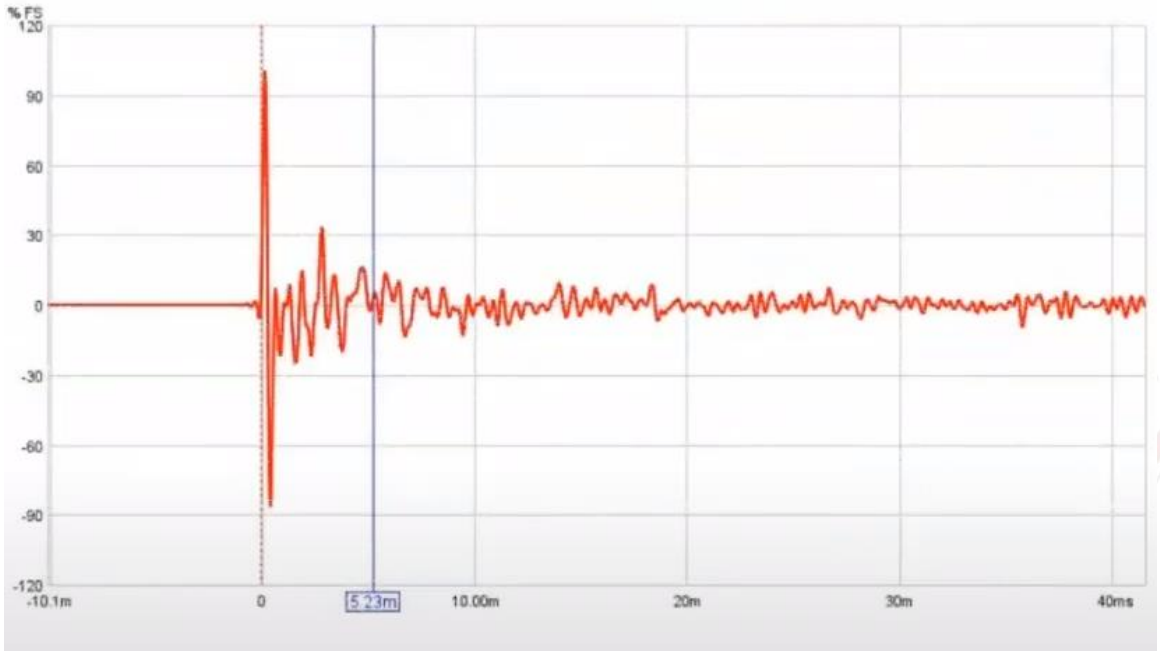
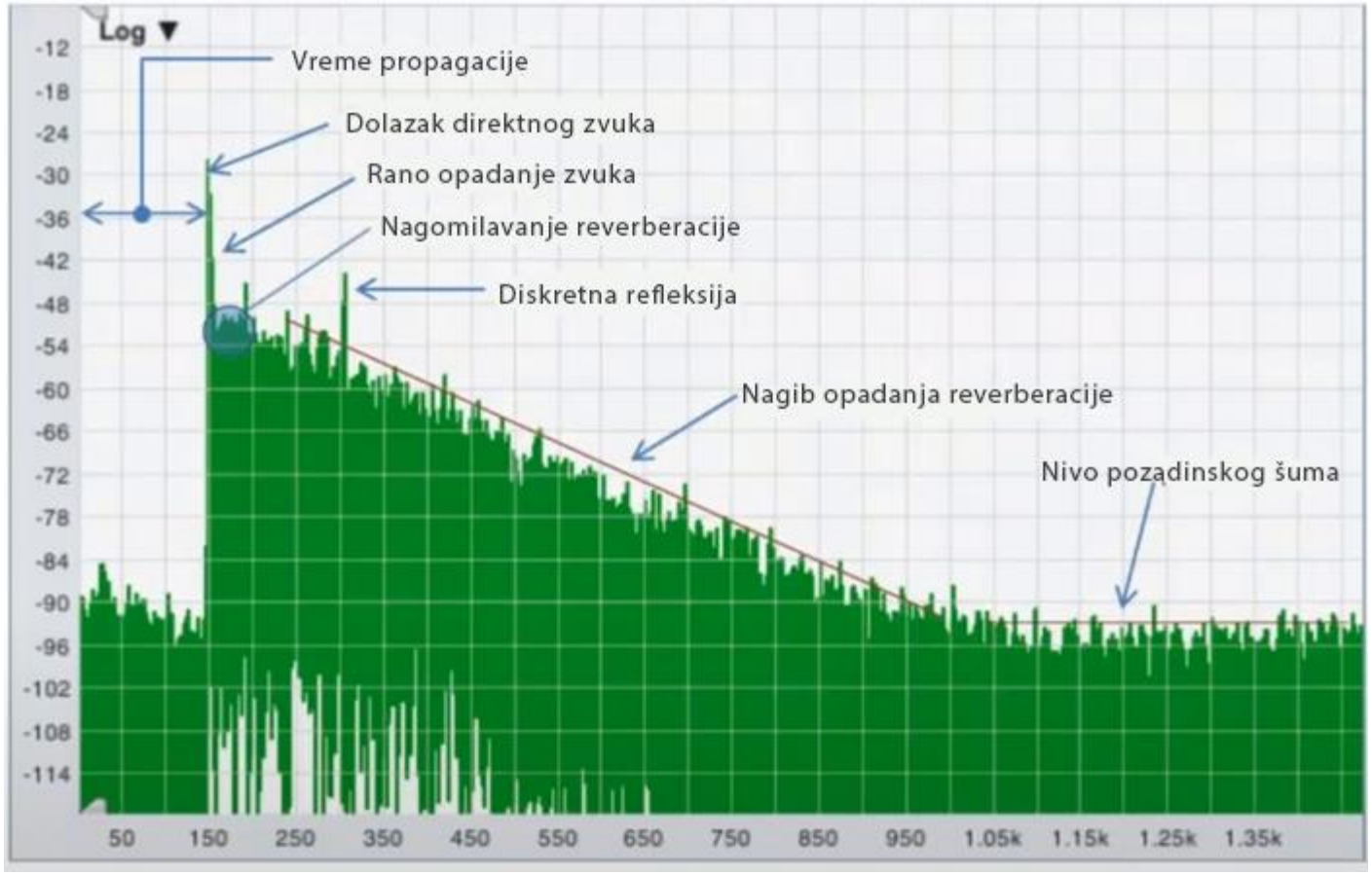
Room acoustics

- Sound in the room is a combination of direct and reflected sound
- Pulse response enables analysis and modeling of acoustic properties of rooms, as well as understanding how sound behaves in certain conditions
- The sound duration is:



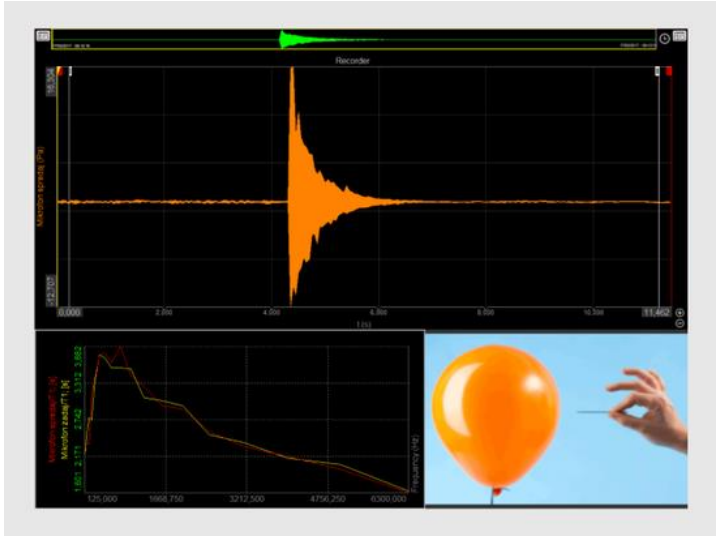


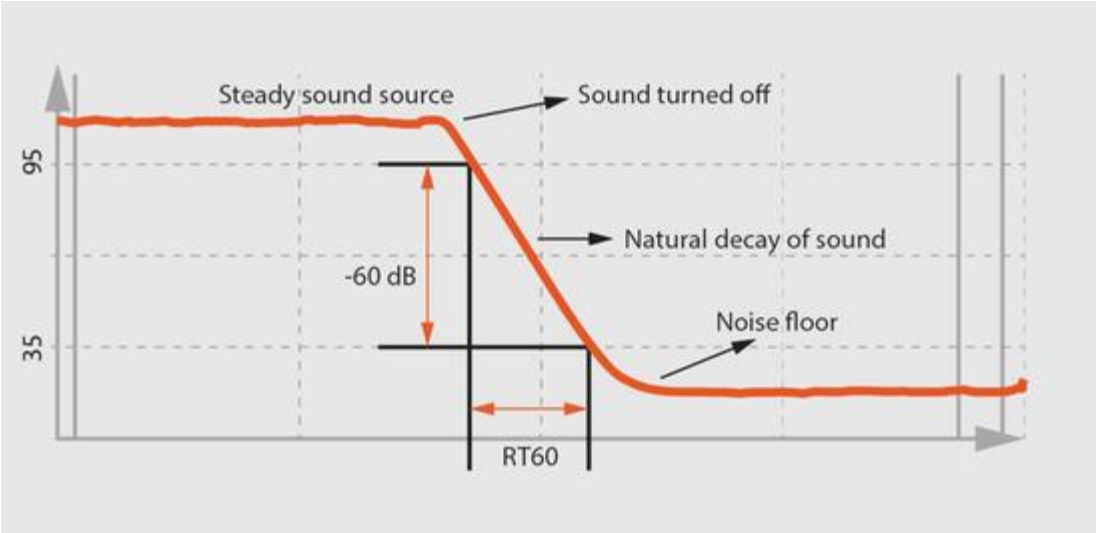
Room acoustics



Room acoustics

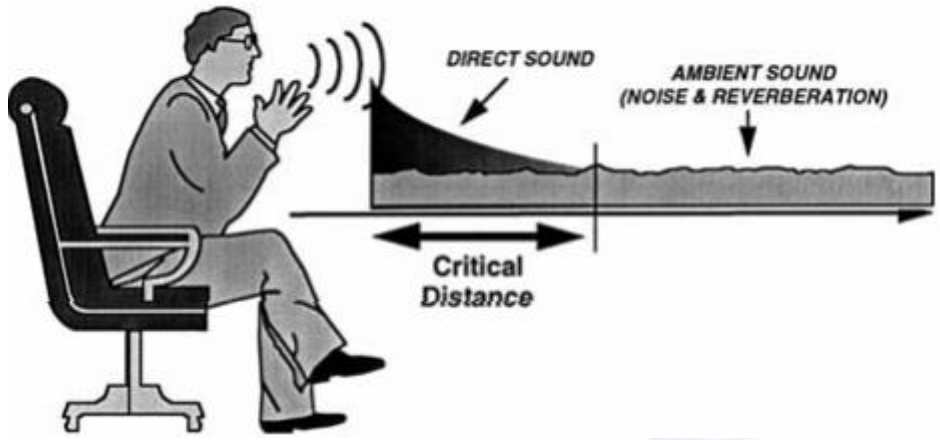
- RT60 (Reverberation Time) is the time it takes for the volume in the room to drop by 60 dB after the sound source stops.
- Pulse response can be measured directly by using a pulse source, such as a gun shot, a balloon burst, or any other sound source that produces a pulse with sufficient bandwidth and energy, and then measuring the time it takes for the volume to drop by 60 dB.
- Longer RT60 time means longer reverberation, which may be desirable in some contexts, such as concert halls, where a rich, full sound is desired.
- Prolonged RT60 time can lead to mixing and loss of speech clarity, especially in rooms where speech intelligibility is key, such as conference rooms or classrooms.





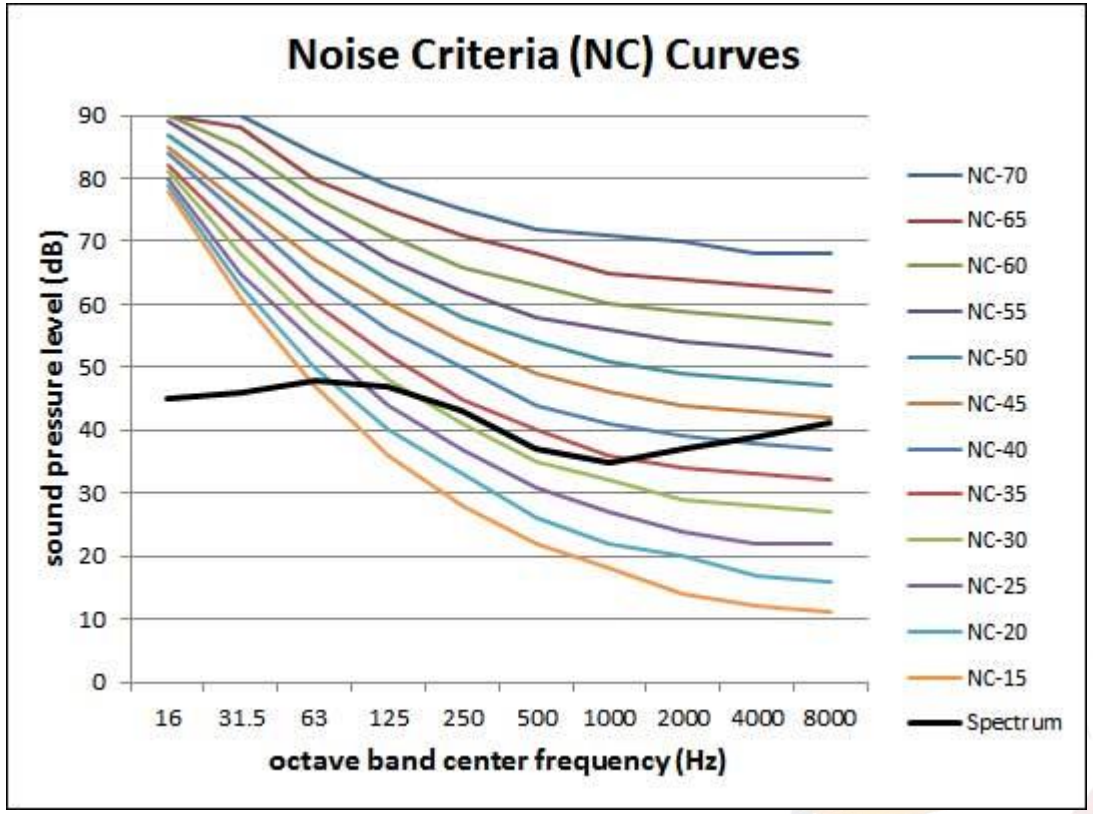
Room acoustics

- Background noise (ambient sound) is sound that occurs naturally in the environment and can be caused by various factors, such as external sounds, air conditioning, human activity or other sound sources.
- Critical distance: the distance from the sound source to the microphone at which the direct sound is at the same level as the ambient sound
- If the sound source is quiet, or if there is constant ambient noise, then the level is high, the critical distance is reduced.
- Background noise measurement: Calibration, Positioning,
- Measurement, Result reading, Result analysis
- Useful tone at least 10dB above ambient noise level



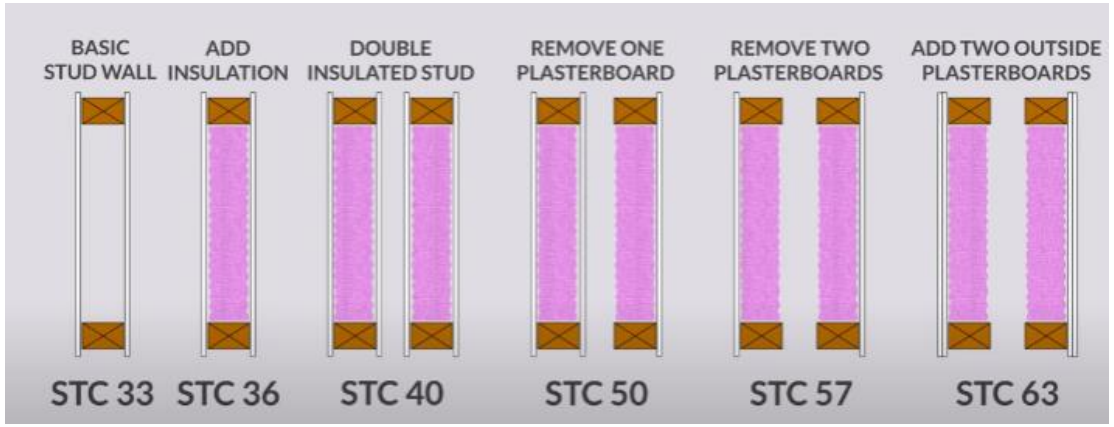
Room acoustics

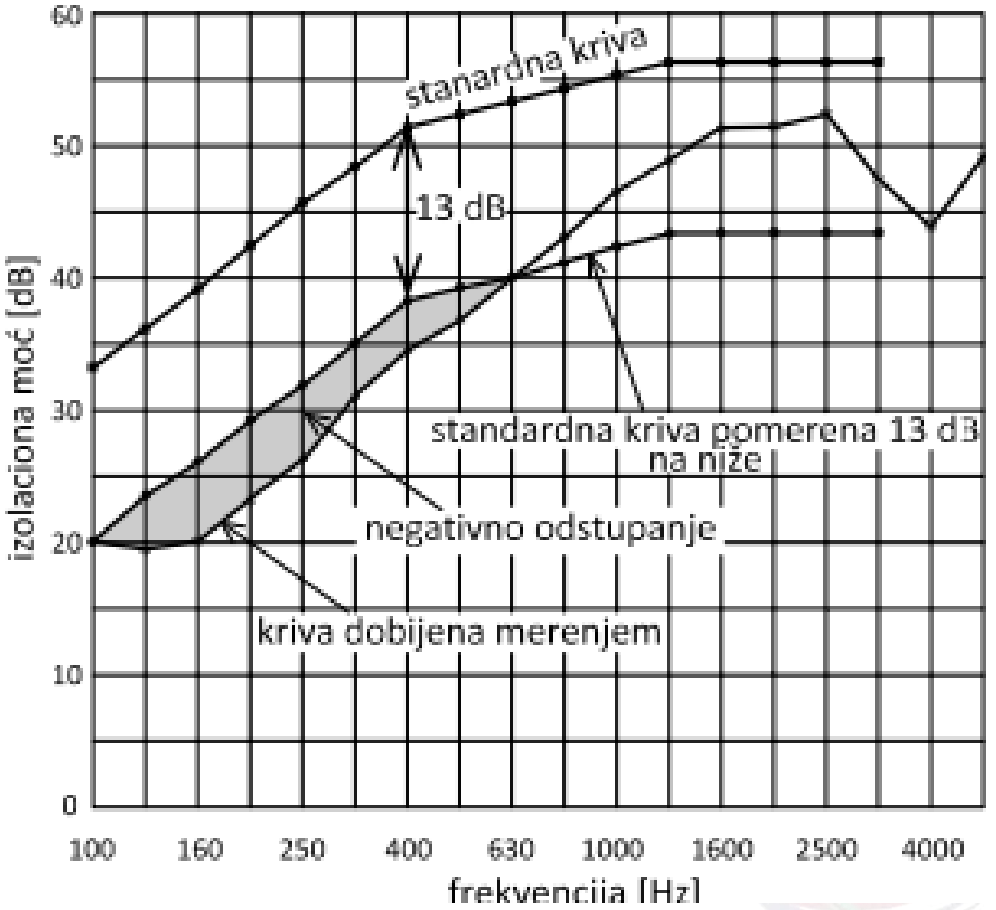
- Noise Criteria (NC), is a standardized system for classifying and measuring indoor noise levels
- The NC system categorizes noise levels based on frequency spectrum and volume, giving numerical designations from NC-15 to NC-80.
- The lower the NC number, the lower the noise level, while the higher NC numbers indicate a higher noise level
- Preferably 20 – 25 for conference rooms
- Problem over 50



Noise measurement

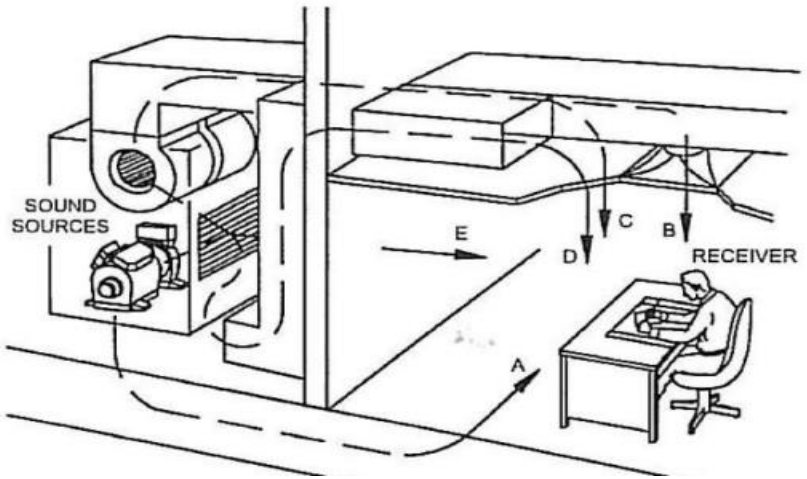
- The sound insulation index of a partition is obtained by comparing the measured results with the so-called standard sound insulation power curve.
- In American literature, instead of insulating power, the Sound Transmission Class (STC) is calculated





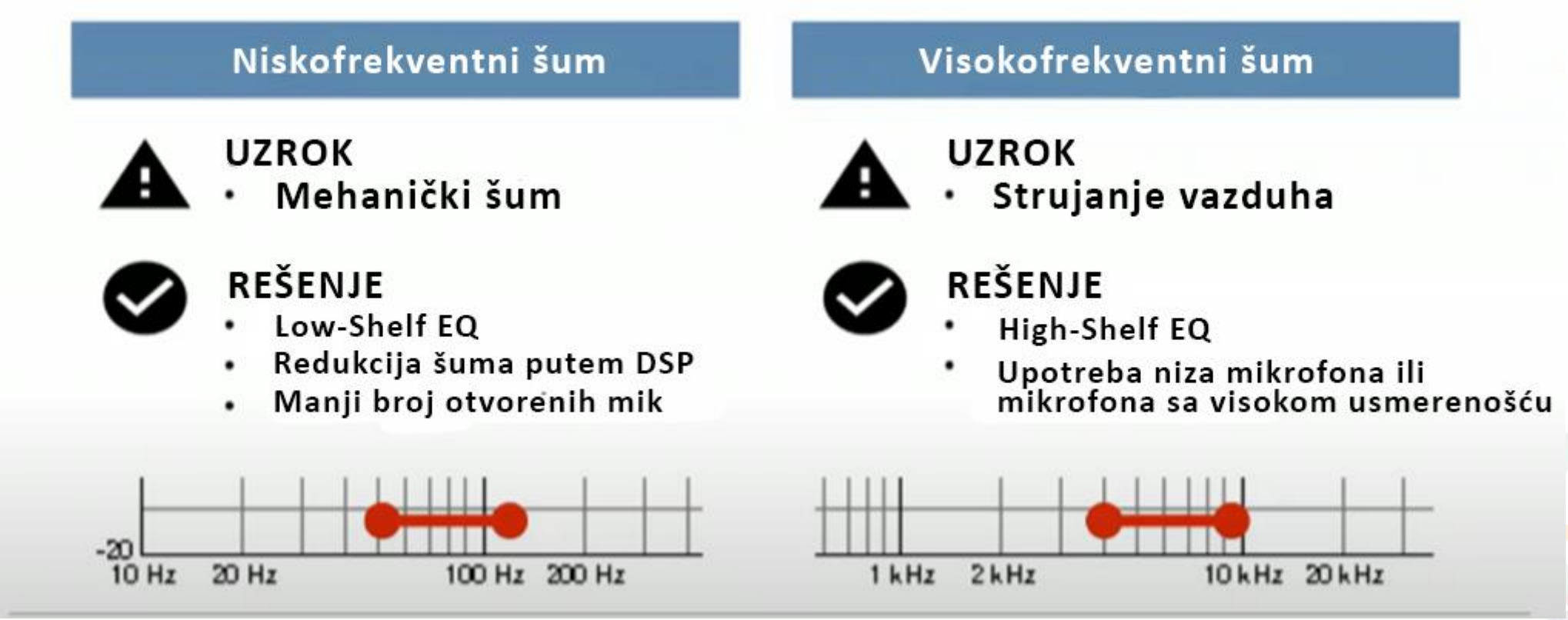
Noise sources

- Air conditioning, heating and ventilation are the most common sources of background noise
- Projectors, traffic, electronic devices….
- Mechanical engineers are required to analyze ventilation/air conditioning noise in consultation with the acoustics engineer



Noise sources

- Air conditioning makes two types of noise:



How to improve room acoustics

- Appropriate sound insulation of room
  - Ensure high STC of walls, ceilings and floors when designing
  - High STC for windows when starting
  - Soundproofing of the air conditioning room
  - Using insulating materials between walls (glass wool, mineral wool, cellulose insulating materials)
  - Using Plasterboard with holes
  - Avoid glass and flat surfaces
  - Rough rule: opening a door or window by only 1% allows as much as 50% of the sound to pass through the opening

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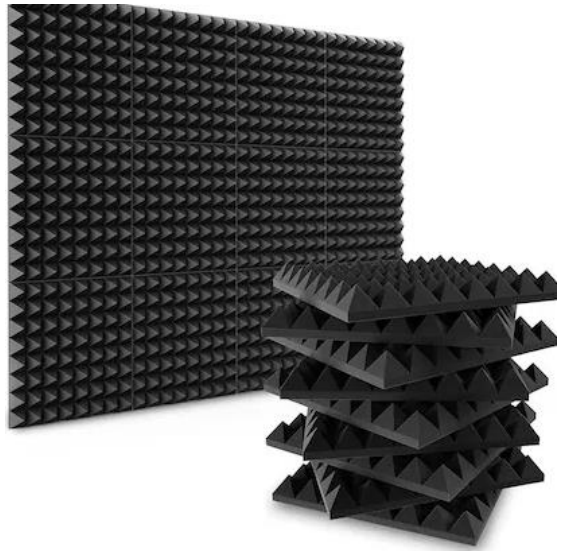
How to improve room acoustics

- Appropriate sound insulation of the room
- Reduction of ambient noise
  - Analysis by a mechanical engineer of the moving parts of the HVAC system
  - Reducing the number of fans in the room
  - Limiting electronic equipment (projectors, active cooling, etc.)
  - Low-noise room location
  - Define the minimum criterion of room noise

How to improve room acoustics

- Appropriate sound insulation of the room
- Reduction of ambient noise or noise levels
- Choosing a room interior
  - Absorbers and diffusers
  - Wall decoration
  - Panels
  - Ceiling system
  - Floor
  - Furniture



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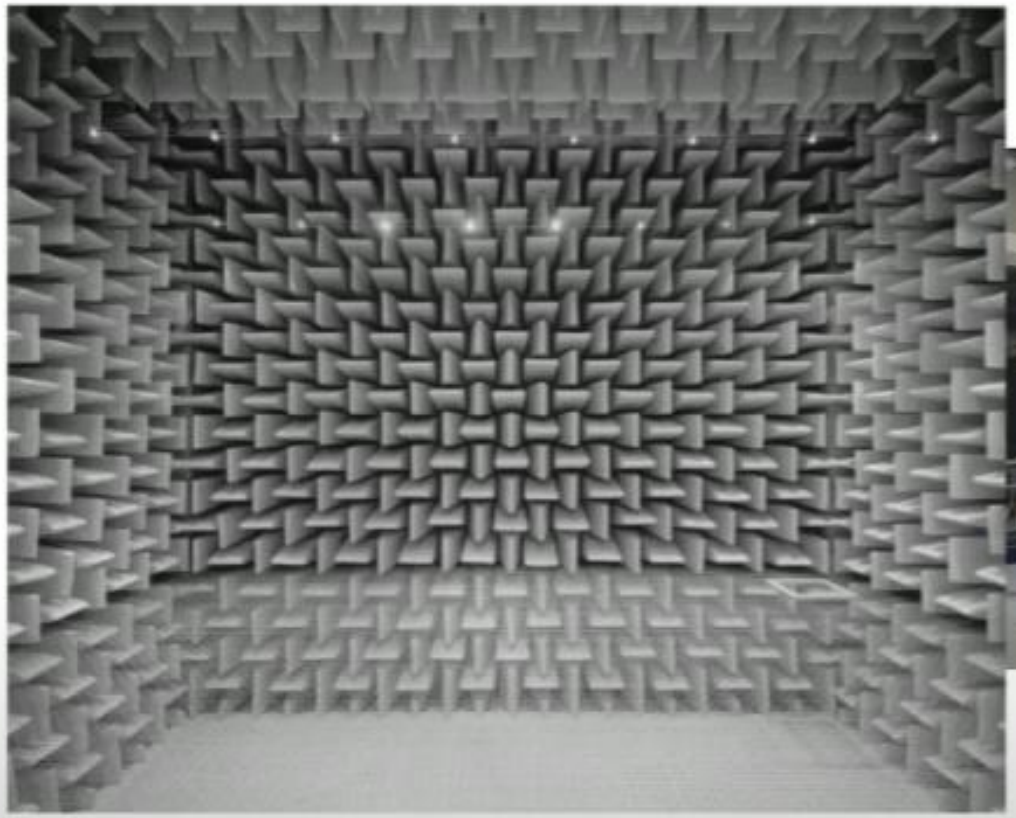
The perfect room?



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Acoustics in TV

•The reverberation time is the time it takes for the sound emitted in a closed room to drop to one millionth of its initial intensity, after the termination of its broadcast, which corresponds to a reduction in the sound level by 60 dB (the reverberation time has elapsed).

•It depends on: room geometry, the absorption coefficient of the walls, floor and ceilings, as well as the number and absorption characteristics of the objects filling the room.

•The **material absorption coefficient varies depending on the sound frequency**, so the reverberation time of the room is not the same for different sound frequencies. **It is more difficult to determine the reverberation time for lower frequencies.**

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Technical conditions for acoustic treatment

- Nature of the facility, size and shape of the facility,
- Condition of the facility
- Basic design criteria for acoustic treatment:
- The maximum recommended reverberation time in medium-frequency TV studios should be a maximum of **0.6s**.
- If the room is already built, the reverberation time should first be measured in its existing condition, and then, based on that, the type of acoustic treatment should be proposed.

Technical conditions for acoustic treatment

•Various absorption materials can be used, as well as single, double, or triple partitions, with glass wool inserted between them or with an air gap **(perforated RIGITON 60×60 panels (KNAUF), with acoustic fabric behind the perforations serving as the absorption material).**

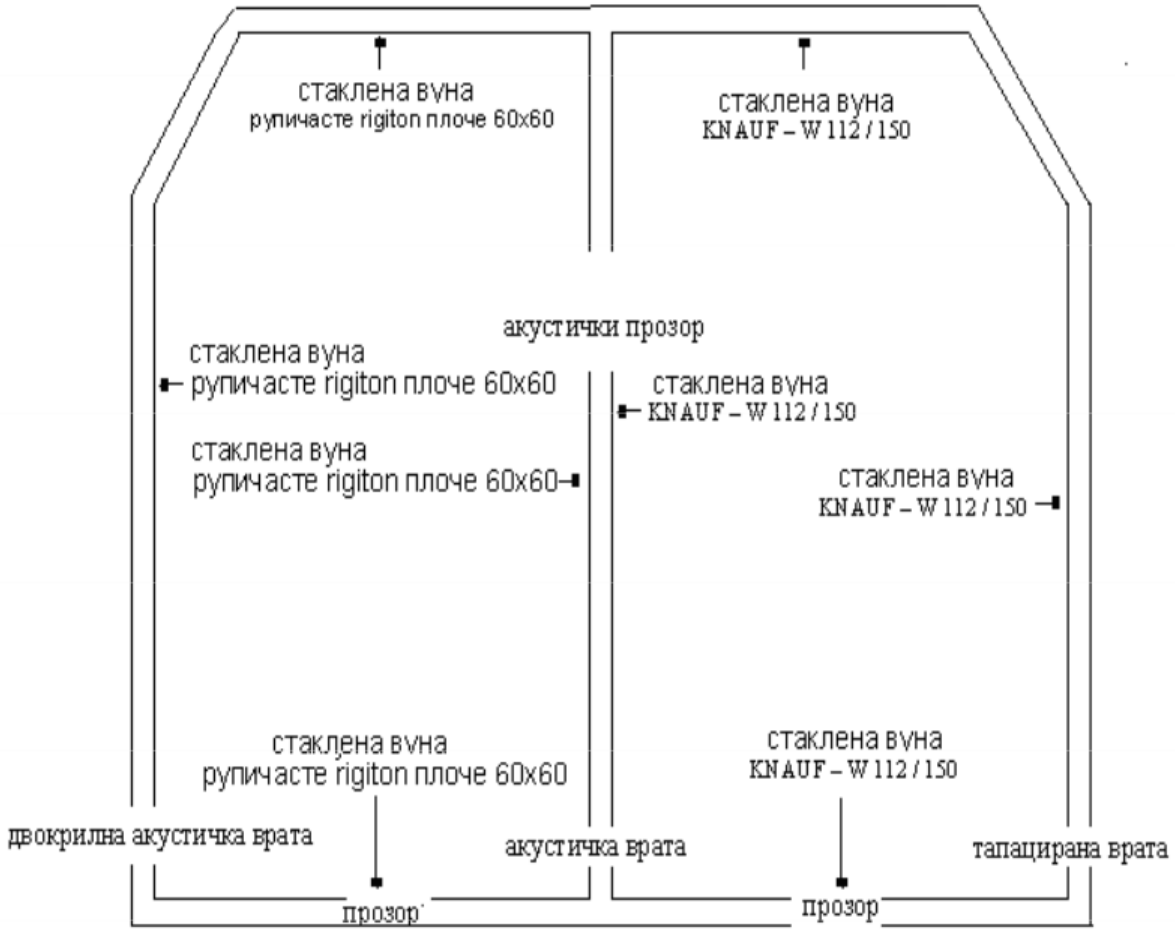
•**RIGITON panels are also installed on the ceiling**.

•It can also be done with double rigips panels (**glass wool + air**) in between –good acoustic and thermal insulation.

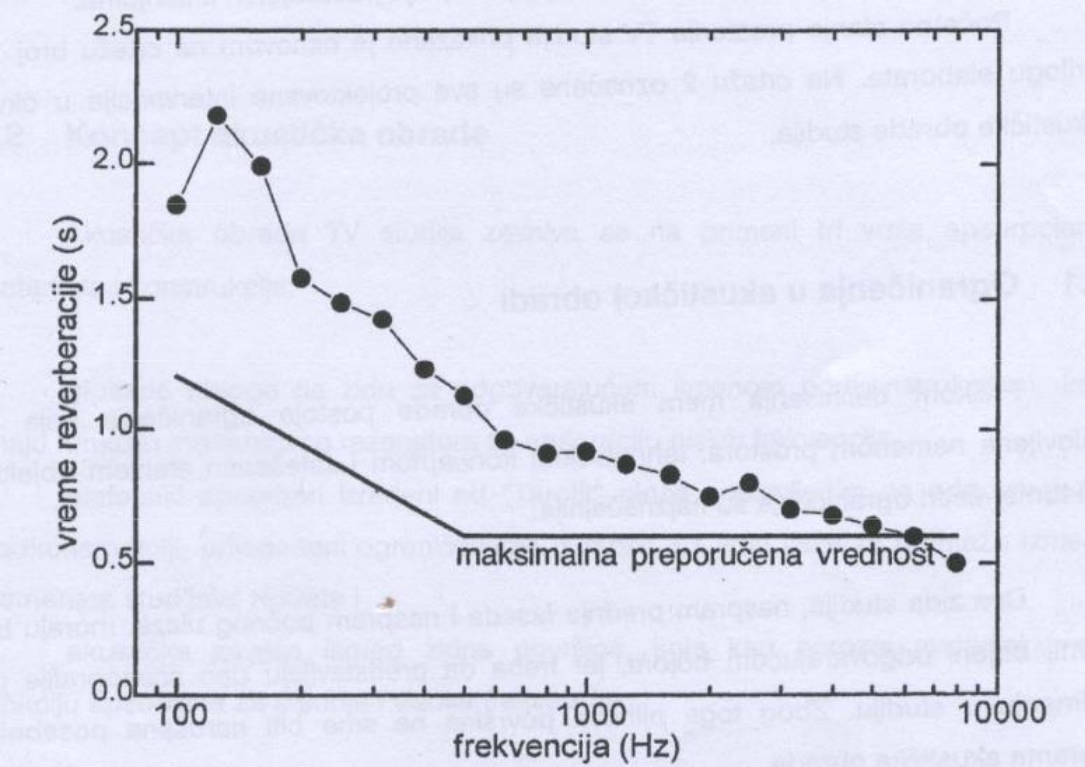
•Gypsum ceiling tiles 60×60 or plasterboards should be installed at an angle if possible (zig-zag or tilted)

•For glass partitions between the utility and TV studios, if the partition is used for camera imaging, the glass should be tilted about 15 degrees due to reflection.

Two-room TV system



Measuring reverberation time in the initial state



Rezultati merenja vemena reverberacije u početnom stanju prostorije TV studija i kriterijum za projektovanje akustičke obrade (maksimalna preporučena vrednost).

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Acoustic Study Processing

•The figure shows that the reverberation time at the lowest frequencies should be reduced.

•Suggestion:

•Eliminate opposing hard, plastered parallel surfaces.

•Install acoustic absorbent material on these walls – Azmafon, AD panels with fabric.

•The wall on which **chrome** is expected should remain flat and painted with the appropriate matte paint (**it should not be acoustically treated**). A suitable canvas can also be used.

•If the studio is low, **about 3m**, the reflectors are placed directly next to the ceiling, in this case, it is not possible to apply acoustic treatment across the entire surface, only between the lighting support elements. Acoustic treatment elements on the ceiling must withstand high temperatures.

•If a curtain or cyclorama is used, it can partially replace acoustic material (thick fabric – has a high absorption coefficient, installed at an appropriate distance from the wall surface, gathered at a 2:1 ratio by stitching along the track).

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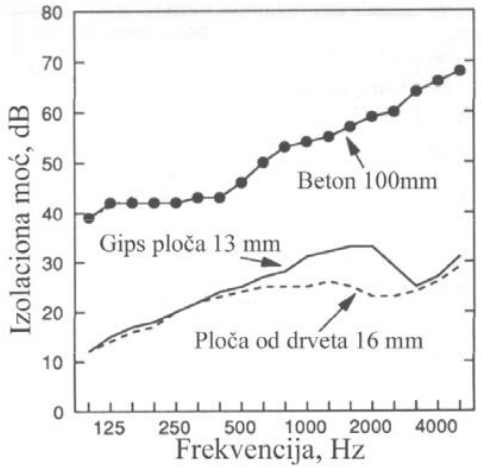
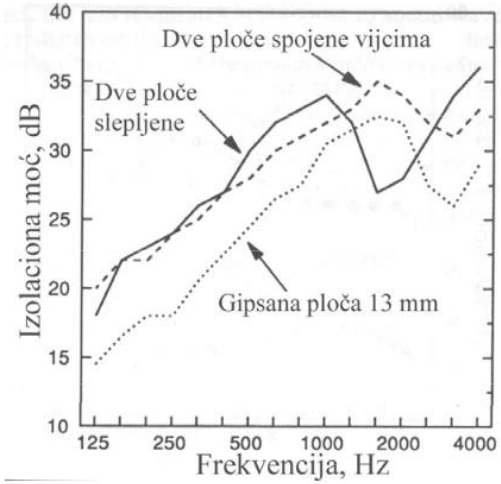
Absorption coefficient in %

Materijal	Frekvencija [Hz]					
	125	250	500	1000	2000	4000
Zid malterisan	1-2	2	2	3	4	5-7
Drvo	1	-	5	-	4	4
Parket	20	15	10	10	9	10
Staklo	10-22	4-6	3	2	2	2
Tepih	4-10	5-15	10-20	20-30	30-40	30-60
Nabrana zavesa	15	35	55	70	70	65
Akustičke ploče	20	35	50	55	60	70
Fotelje	1-25	15-30	2-35	3-45	4-5	35-45
Apsorpcija po osobi [m^2]	0,15	0,3	0,5	0,55	0,6	0,5

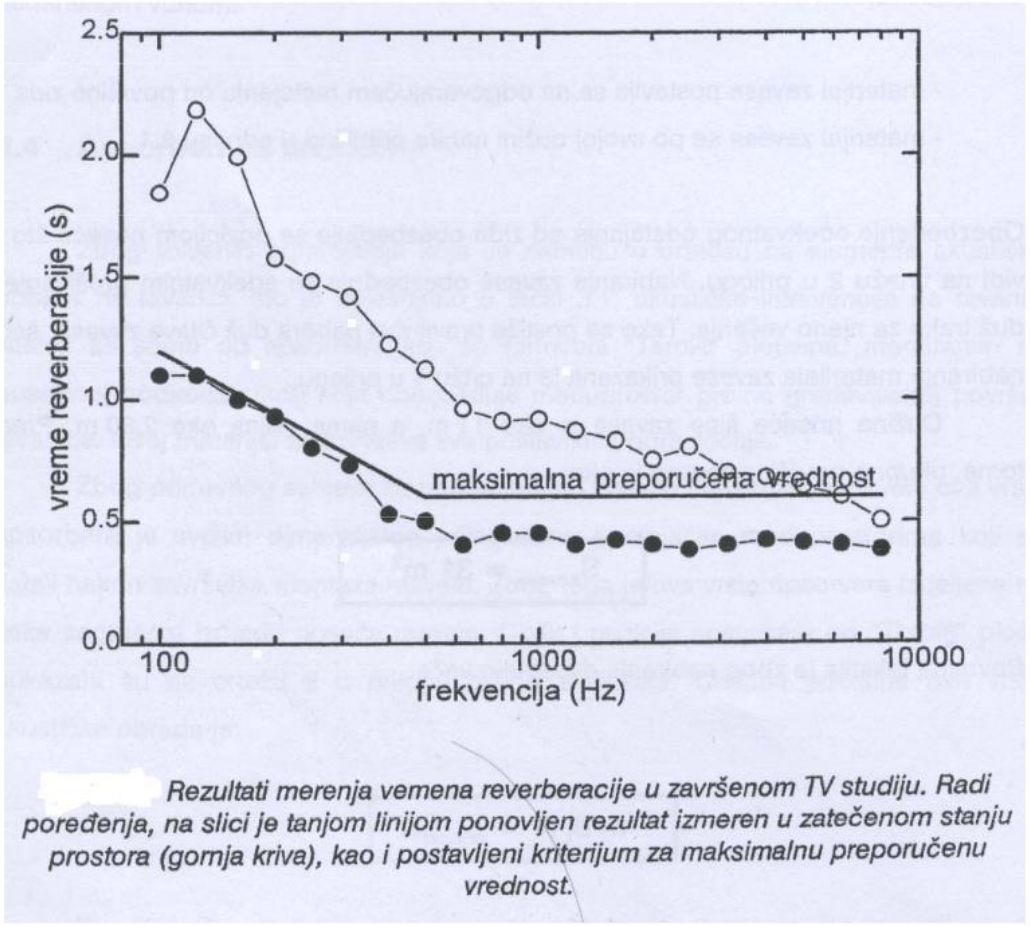
Material insulation power





Ciklorama

Measuring reverberation time in post-processing



Rezultati merenja vemena reverberacije u završenom TV studiju. Radi poređenja, na slici je tanjom linijom ponovljen rezultat izmeren u zatečenom stanju prostora (gornja kriva), kao i postavljeni kriterijum za maksimalnu preporučenu vrednost.

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MICROPHONES

What is a microphone?

•The microphone is an electro-acoustic converter that converts sound waves into an electrical signal.

•The basic function is to enable the transmission and processing of sound in technical systems.

•The first microphones were created at the end of the 19th century for telephony purposes.

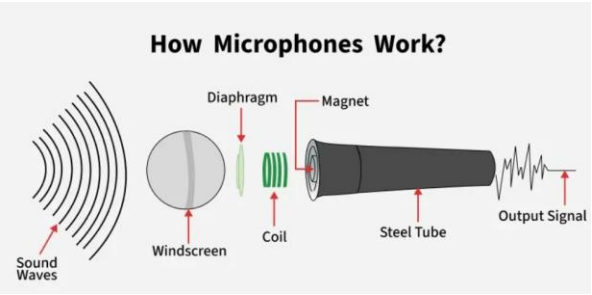
•Today, microphones are key in the media, music and telecommunications.

•Without a microphone, recording, broadcasting, and transmiting audio would not be possible.

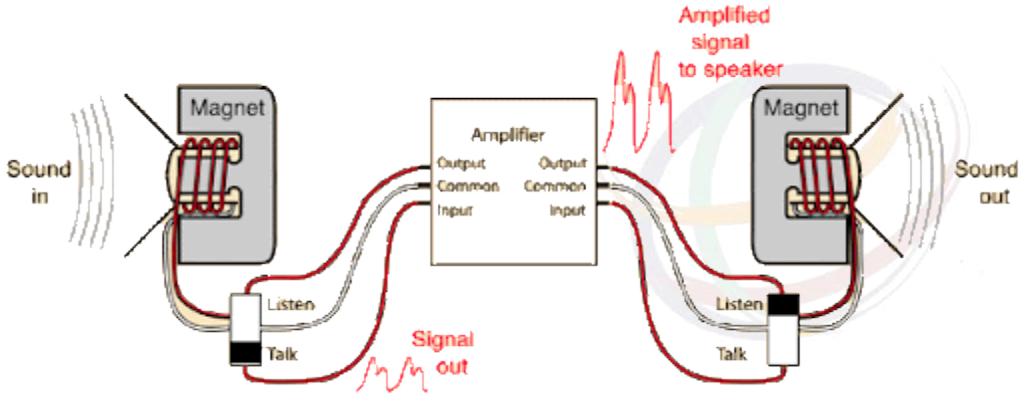
•Each type of microphone has a specific purpose and characteristics.

•The microphone is the first and one of the most important elements of the audio chain.

Principle of Operation



- The microphone converts acoustic pressure into electrical voltage.
- The vibration of the diaphragm is accompanied by changes in sound waves.
- The movements of the diaphragm cause changes in the microphone's electrical circuit.
- Dynamic microphones use electromagnetic induction.
- Capacitor microphones work to change the capacity.
- Tape microphones use vibrations of a thin metal strip in a magnetic field.
- The electrical signal is weak and requires mic preamp.



Historical development of the microphone

- The first microphones were used in telephony in the late 1800s.
- Carbon microphones were dominant in early telecommunications.
- Dynamic microphones appeared in the 1930s (Shure 55).
- Condenser microphones have been developed for high audio fidelity in the studio.
- Tape microphones popular in radio and studios in the mid-20th century.
- Wireless microphones were introduced in the 1950s and 1960s.
- Contemporary trends include USB and network (Dante) microphones.

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Microphone application

- In television, microphones are used for dialogue, interviews and broadcasting events.
- The film uses boom and lavalier microphones for dialogue and ambience.
- Condenser and dynamic microphones for instruments and vocals are used in music.
- In radio, the microphone is crucial for speech and live broadcasts.
- In telecommunications, microphones are found in phones and computers.
- Special measurement microphones are used in science and industry.
- In everyday life, they are present in smartphones and laptops.

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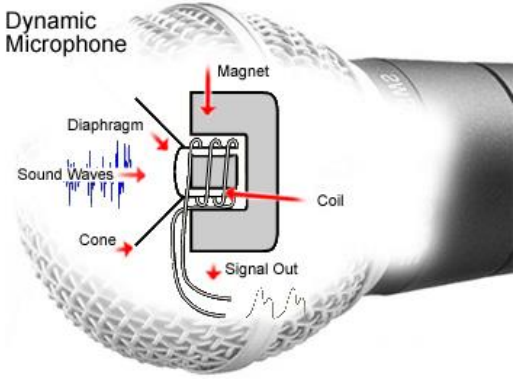
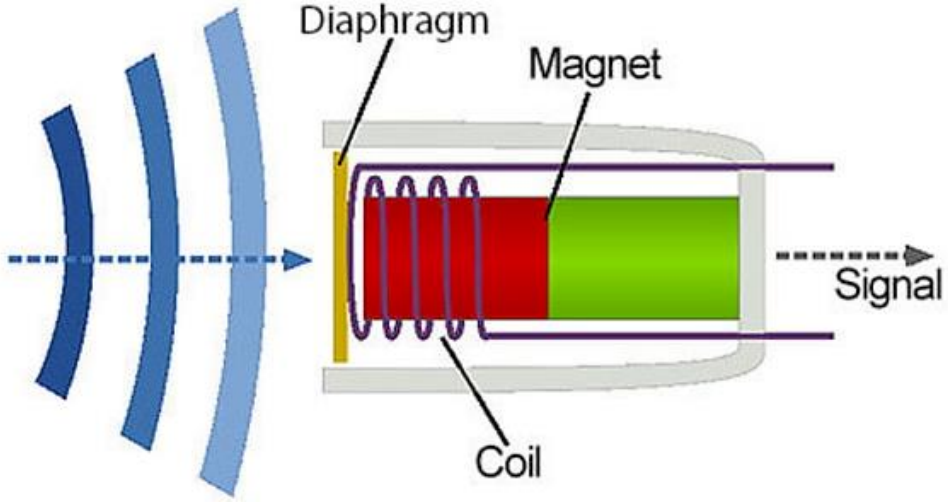
Microphone partitioning

- Principle of operation: dynamic, capacitor, tape, electret.
- Division by orientation: omni, cardioid, supercardioid, figures-8.
- Division by application: studio, lavalier, boom, manual, boundary.
- Split by connection: wired and wireless microphones.
- Distribution by signal format: analog and digital microphones.
- Capsule size distribution: large diaphragm and small diaphragm.
- Multifunctional microphones have the ability to change polar patterns.

Dynamic microphones: working principle

- The dynamic microphone operates on the principle of electromagnetic induction.
- Sound moves the diaphragm which is connected to a coil within the magnetic field.
- The movement of the coil generates an electrical signal proportional to the sound.
- They do not require power to operate.
- They are robust and resistant to physical shocks.
- They tolerate high sound pressure levels (SPL) well.





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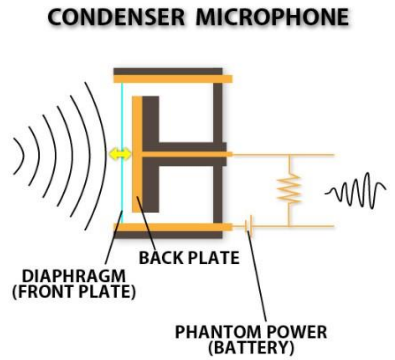
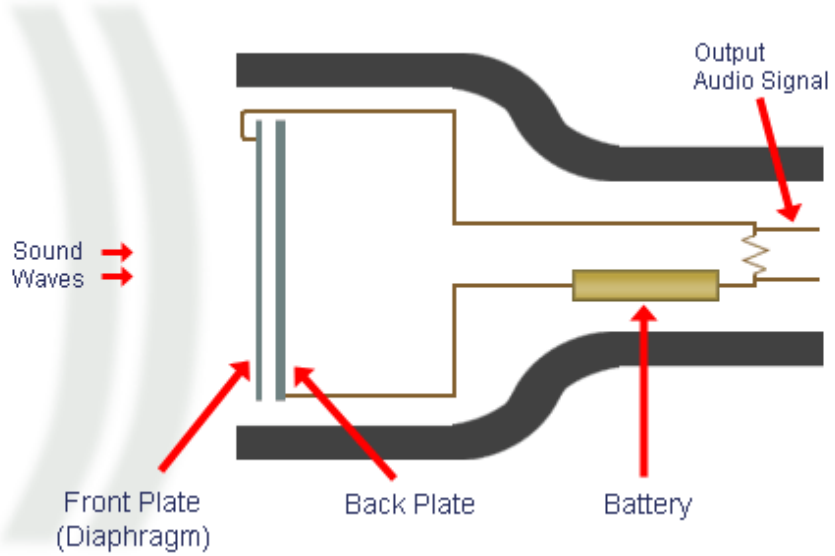
Dynamic microphones: application

- They are most commonly used at concerts and live events.
- Suitable for vocals in noisy environments.
- They have natural resistance to background noise.
- They reject microphone (feedback) well.
- They are long-lasting and cheaper than condenser microphones.

Condenser microphones: working principle

- The condenser microphone operates on the principle of variable capacity.
- The diaphragm and back plate form a condenser.
- The sound moves the diaphragm, changing the capacity and creating a signal.
- They need a phantom power supply (+48V).
- They are more sensitive to detail and high frequencies.
- They have a wider frequency range than dynamic microphones.
- They are used where high audio fidelity is required.



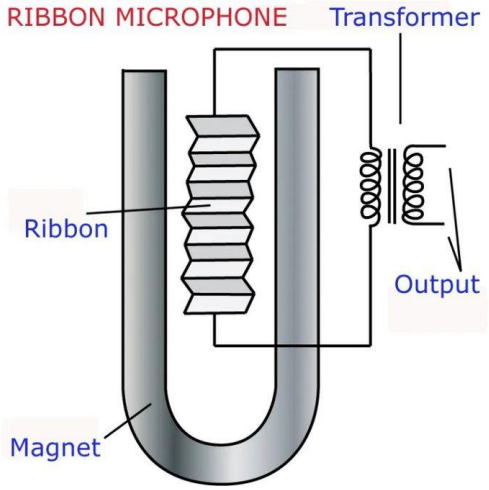


Condenser microphones: application

- Standard in instrument recording studios.
- They are used in radio and TV studios.
- Suitable for recording acoustic instruments.
- They are often used as overhead drum mics.
- They convey the dynamics and details in the sound very accurately.
- They can be large diaphragm or small diaphragm.
- Directional microphones are often condenser
- Very sensitive to ambient noise and room.

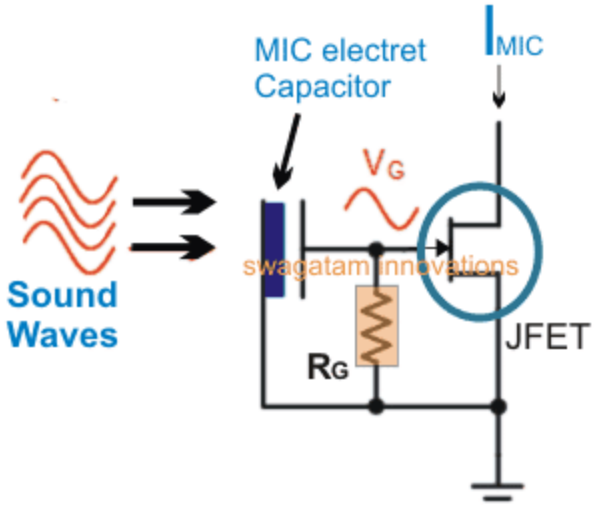
Ribbon microphones

- They use a thin metal strip placed in a magnetic field.
- The sound moves the tape and generates a signal.
- They have a warm and natural sound.
- They most often have a figure-8 polar pattern.
- They are sensitive to mechanical damage.
- Not suitable for extremely high SPL levels.
- Popular in vocal and guitar amplifier studios.



Electret Condenser Microphones

- A special type of capacitor with a constantly charged membrane.
- They do not require a high phantom power supply.
- Small and compact, ideal for lavalier microphones.
- They are used in mobile devices and laptops.
- They have a good price-to-quality ratio
- Often integrated into wireless lapel systems.
- Sensitive to noise and RF interference.

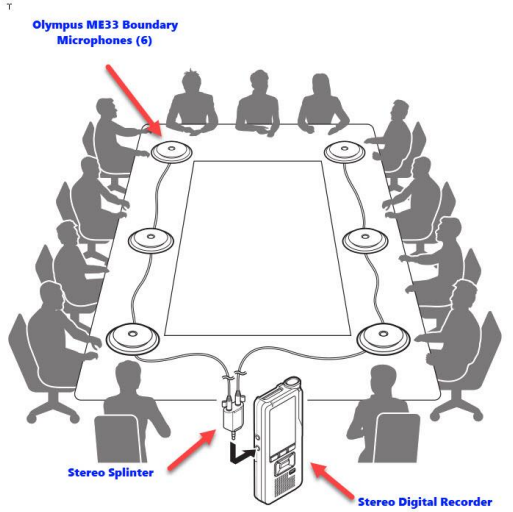


USB Microphones

- They connect directly to the computer via a USB port.
- They have a built-in digital audio interface solution.
- Popular for podcasting and streaming.
- Suitable for home studies and content creators.
- Cheaper than professional XLR microphones.
- Limited options in terms of quality and settings.

Boundary microphones

- Flat microphones placed on the surface (table, floor).
- They use sound reflection for better response.
- They are used in conference rooms.
- Suitable for recording group conversations.
- Some models use cardioid capsules.
- They are also used in theatre for recording ambient sound.
- Often connected via XLR or mini-jack.



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Specialized microphones

- Piezo microphones for instrument vibration capture.
- Binaural mics with ear mimics for 3D audio.
- Contact microphones for special effects and experimental music.
- Measurement microphones (flat response).
- Waterproof microphones for special applications.
- Sport microphones with directional capsules.
- Wireless clip-on microphones for small devices.

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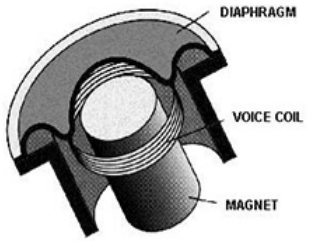
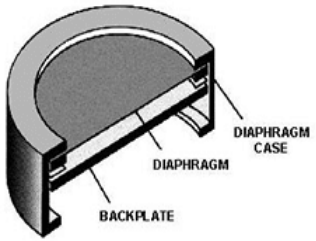
Dynamic vs Condenser

- Dynamic microphones are more resilient and cheaper.
- Condenser microphones are more sensitive and expensive.
- They are dynamically ideal for fieldwork and noisy environments.
- Condensers are better for studio and precision recording.
- Dynamically, they have a narrower frequency range.
- Condenser have a wider range and a better transient response.
- The choice depends on the purpose and environment.



Dynamic



Condenser

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Examples of TV production microphones

- Lavalier microphones for managers and guests.
- Shotgun microphones on a boom stick.
- Dynamic microphones for reporters in the field.
- Condenser microphones for studio shows.
- Wireless systems for the free movement of speakers.
- Boundary microphones for panel discussions.
- Microphone on camera for backup sound.

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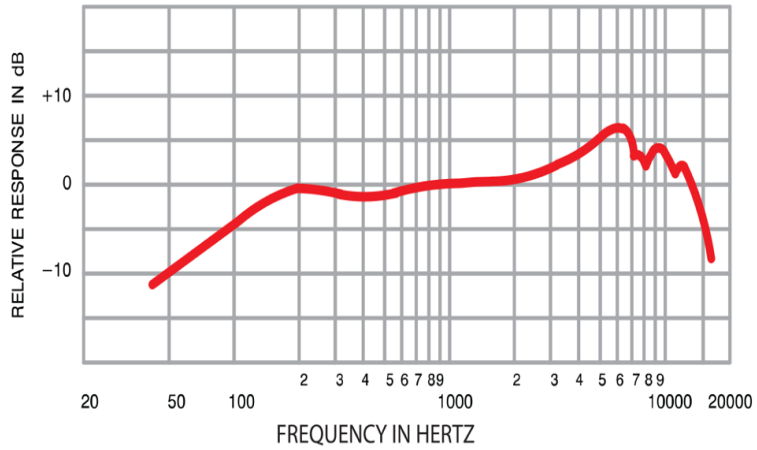
Film and terrain microphone examples

- Shotgun microphones on boom dialogue holder.
- Lavalier microphones hidden under actors' clothes.
- Binaural microphones for special effects.
- Portable recorders with integrated microphones.
- Wireless systems for mobile scenes.
- Contact microphones for special sound effects.
- Microphone combination for ambience and voice.

Microphone characteristics

- The frequency range indicates which frequencies the microphone can reproduce.
- The typical range for voice microphones is 80 Hz to 15 kHz.
- The studio condenser microphones have a wider range (20 Hz – 20 kHz).
- Dynamic microphones often have a narrower range, but tolerate more SPL.
- A wider frequency range allows for more natural sound reproduction.
- It is important when choosing a microphone for a vocal or instrument.
- The flatness of the response in the range is as important as the width.



Microphone characteristics

•Sensitivity indicates how strongly the microphone converts an acoustic signal into an electrical one.

•Measured in millivolts per pascal (mV/Pa).

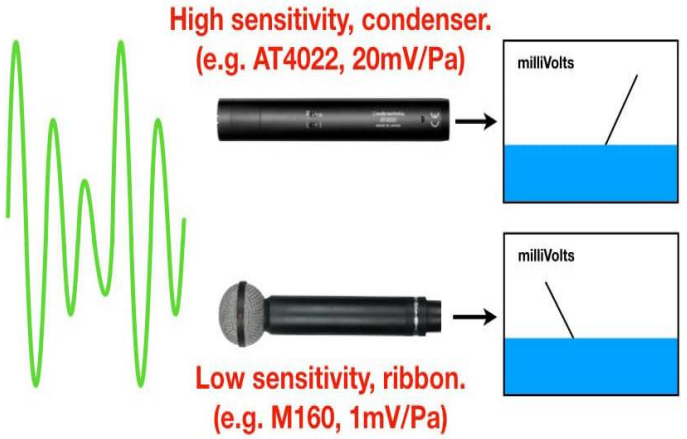
•Condenser microphones are more sensitive than dynamic microphones.

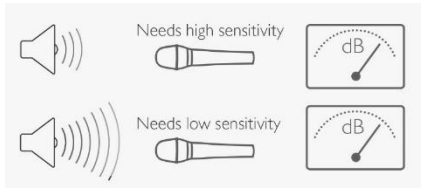
•Higher sensitivity means a better response to quiet sounds.

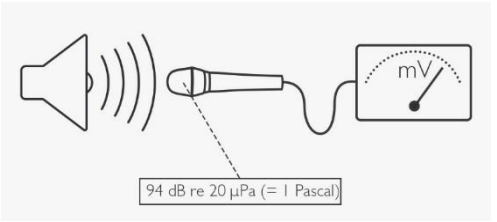
•The lower sensitivity is suitable for recording loud sources.

•The sensitivity balance and the SPL determines the purpose of the microphone.

•Example: DPA 4060 has a high sensitivity for detailed dialogue.

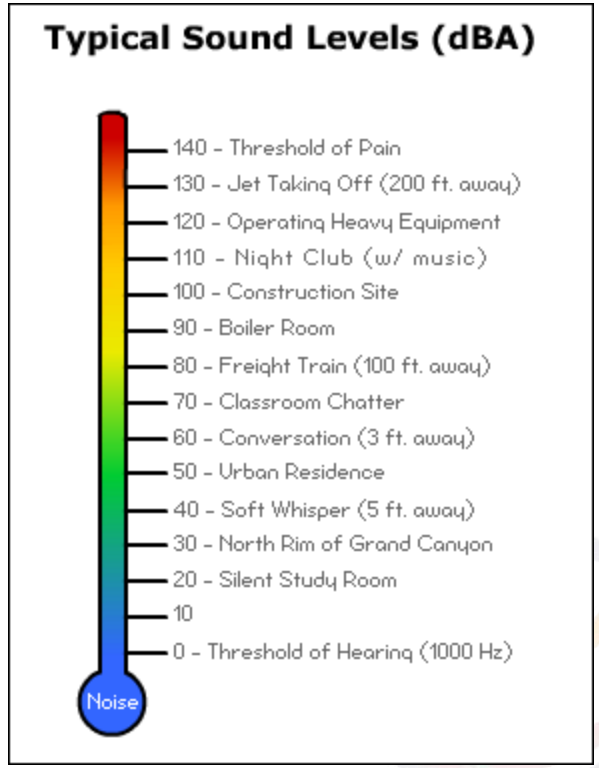






Microphone characteristics

- The SPL indicates the maximum sound pressure that the microphone can withstand.
- Dynamic microphones withstand over 150 dB SPL.
- Condenser microphones have a lower threshold but better precision.
- Exceeding the SPL causes distortion and damage.
- An important parameter for recording drums and amplifiers.
- Microphones for singers usually tolerate about 130–140 dB SPL.
- The SPL should always be aligned with the preamplifier and gain.



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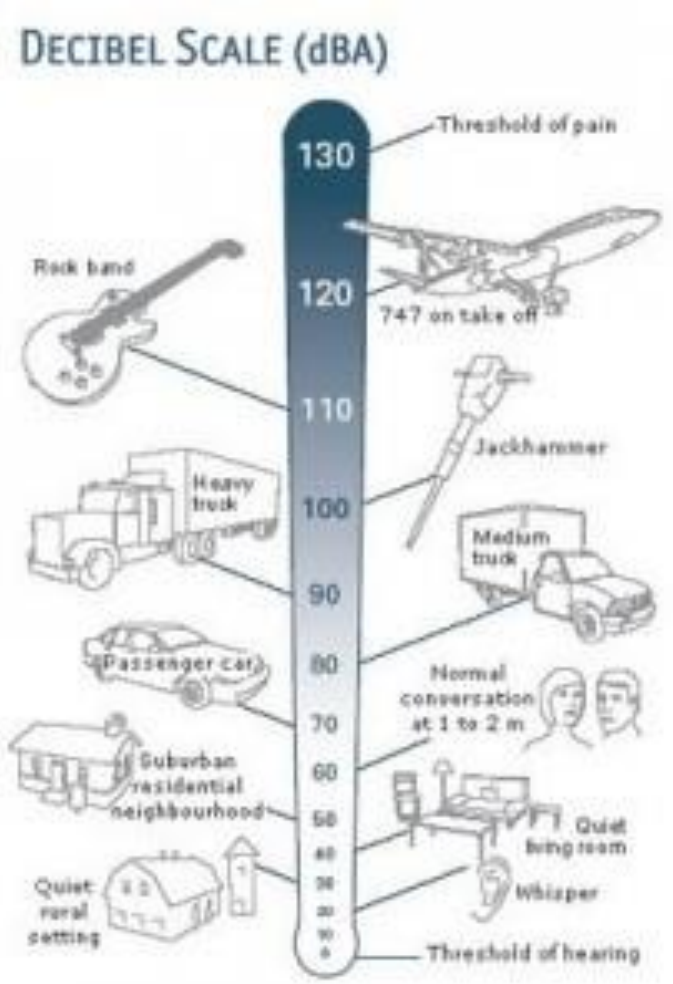
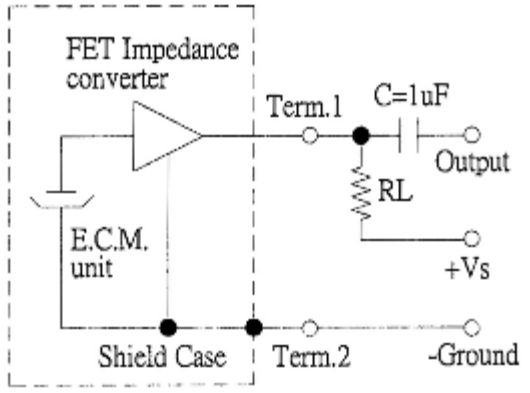
09

Table of sound levels *L* and corresponding sound pressure and sound intensity			
Examples	Sound Pressure Level L_p dBSPL	Sound Pressure *p* $N/m^2 = Pa$	Sound Intensity *I* W/m^2
Jet aircraft, 50 m away	140	200	100
Threshold of pain	130	63.2	10
Threshold of discomfort	120	20	1
Chainsaw, 1m distance	110	6.3	0.1
Disco, 1 m from speaker	100	2	0.01
Diesel truck, 10 m away	90	0.63	0.001
Kerbside of busy road, 5 m	80	0.2	0.0001
Vacuum cleaner, distance 1 m	70	0.063	0.00001
Conversational speech, 1m	60	0.02	0.000001
Average home	50	0.0063	0.0000001
Quiet library	40	0.002	0.00000001
Quiet bedroom at night	30	0.00063	0.000000001
Background in TV studio	20	0.0002	0.0000000001
Rustling leaf	10	0.000063	0.00000000001
Threshold of hearing	0	0.00002	0.000000000001



Microphone characteristics

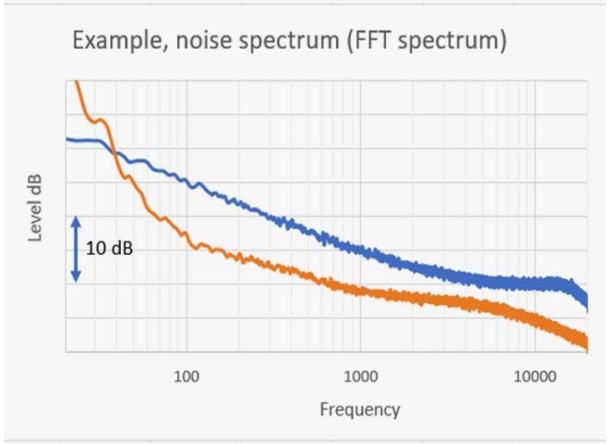
- Impedance is the resistance a microphone provides to an electrical signal.
- The low impedance (<200 Ω) is suitable for professional equipment.
- High impedance (up to 1000 Ω) is found in cheaper microphones.
- Low impedance allows for longer cables without signal loss.
- Poorly matched impedance causes loss of quality.
- Professional microphones use low impedance XLR connections.
- Wireless systems also mimic low-impedance output.



Schematic Diagram **RL=2.2KΩ**

Microphone characteristics

- Self-noise is the internal noise generated by the microphone without a signal.
- Condenser microphones have a higher self-image than dynamic ones.
- Measured in decibels (dBA).
- Typical values are 7–20 dBA for studio microphones.
- A smaller self-exposure is better for capturing a quiet atmosphere.
- Microphones for film and nature recordings require minimal self-noise.
- Dynamic microphones have almost no noticeable self-noise.



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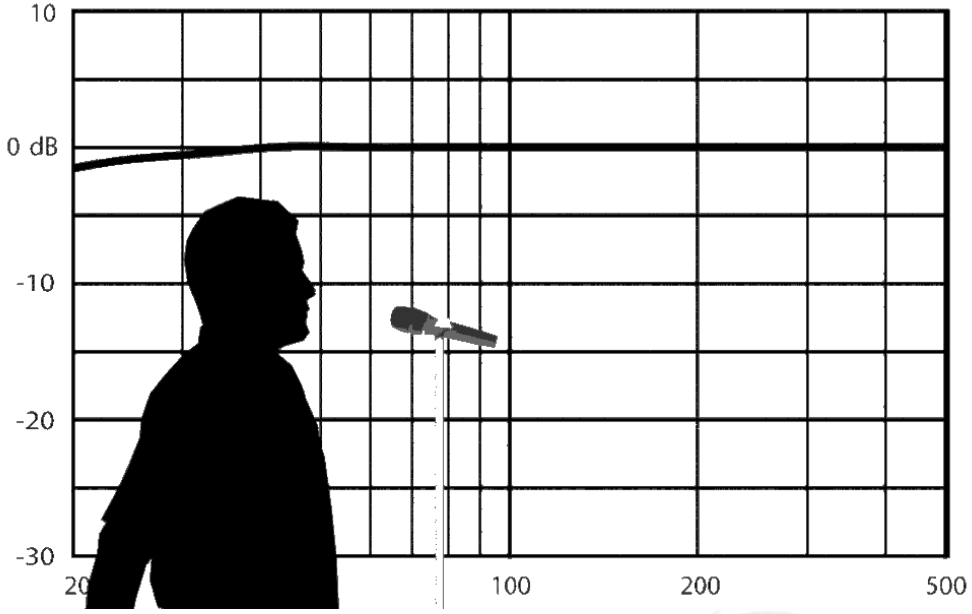
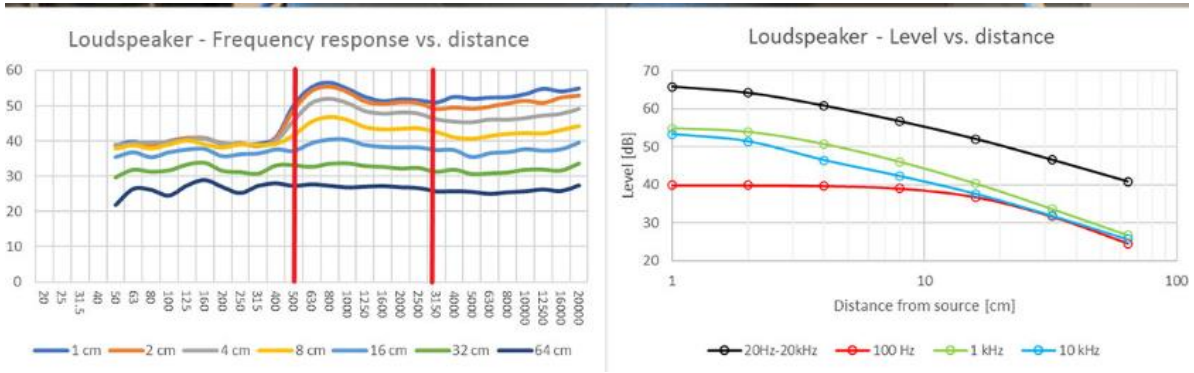
Microphone characteristics

- Dynamic range is the difference between the quietest and loudest signal.
- Microphones with a wider dynamic range convey more detail.
- Condenser microphones have a better dynamic range.
- Dynamic microphones are more limited but more robust.
- Wider dynamic range is important in the studio and for acoustic instruments.
- In broadcasting, it is often less important because the sound is processed.
- For film and music, a wider range means more natural sound.

Microphone characteristics

- The proximity effect is the amplification of the bass frequencies near the source.
- They are most pronounced in cardioid microphones.
- Omnidirectional microphones do not have this effect.
- It can be used creatively for a warmer vocal sound.
- Excessive proximity may cloud the sound.
- It is often mitigated using pop filters and EQ.
- An important factor in microphone placement.





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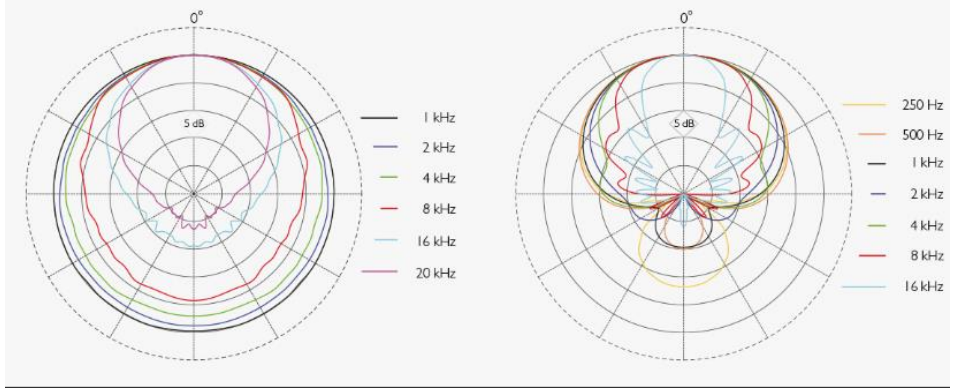
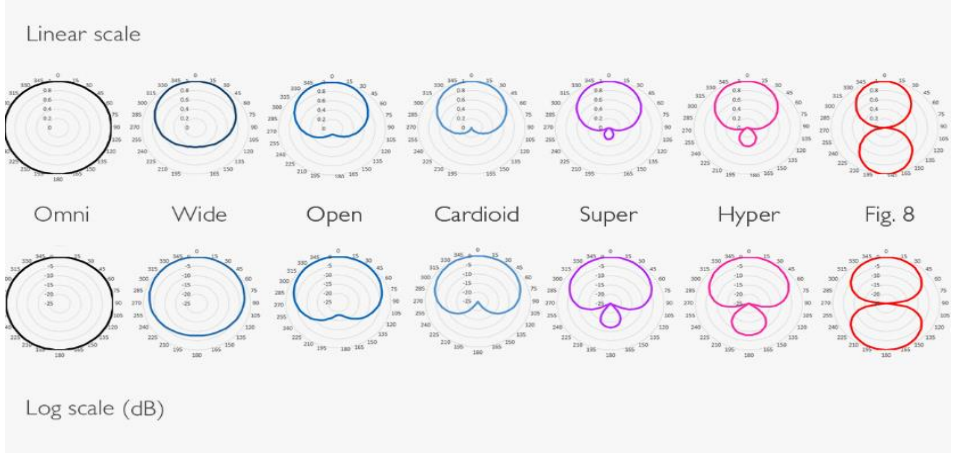
Microphone characteristics

- Linear response means faithfully transmitted sound without coloration.
- Studio microphones tend towards linearity.
- The color response emphasizes certain frequencies.
- Dynamic microphones often amplify intermediate frequencies.
- A colorized response may be desirable for live vocals.
- Linear response is ideal for measurements and mastering.
- The choice depends on the application and the desired sound.

What are polar patterns

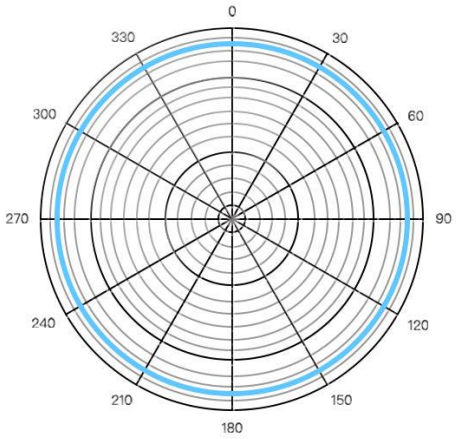
- The polar pattern shows which directions the microphone is receiving sound from.
- Each form has its own advantages and limitations.
- It is defined in relation to the axes of the microphone (0°, 90°, 180°).
- The most common patterns are omni, cardioid, supercardioid, and figure-8.
- There are also specialized forms (shotgun, lobar).
- In the datasheet, it is displayed as a polar diagram.
- The choice of pattern depends on the acoustics and the purpose of the recording.





Omnidirectional microphone

- It equally captures sound from all directions.
- Ideal for capturing ambient sound.
- It does not create a proximity effect.
- It most naturally conveys the acoustics of space.
- It cannot isolate the source from background noise.
- Suitable for use in a studio with good acoustics.
- It is often used in lavalier microphones.



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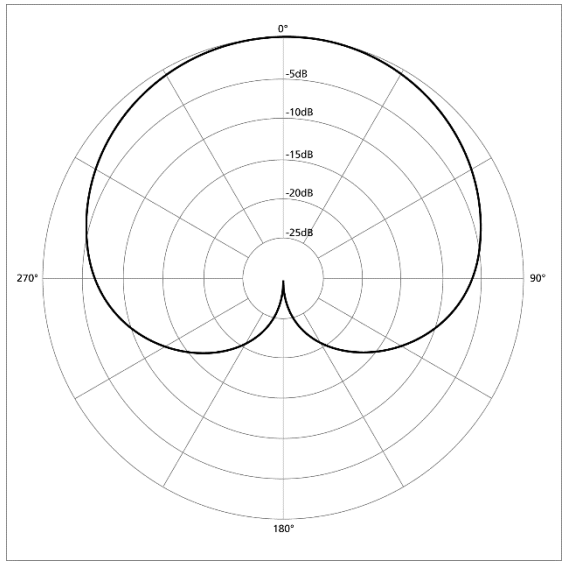
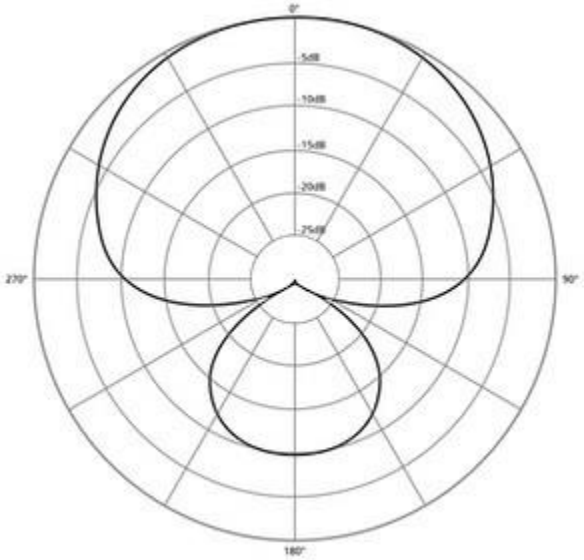
Cardioid microphone

- The most common polar pattern in practice.
- It captures the most sound in front of the microphone (0˚).
- Rejects the sound from the rear (180˚).
- It has a pronounced proximity effect.
- Suitable for speaking and singing live.
- It is well used in noisy rooms.
- Most often with dynamic microphones (e.g. Shure SM58).



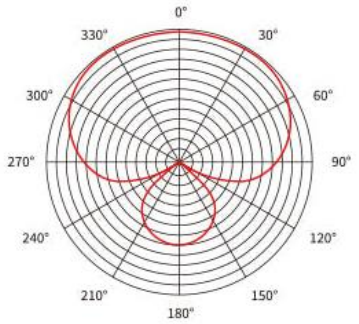
Supercardioid microphone

- More directional than a cardioid microphone.
- It has a narrow main beam in front and a small lob behind.
- It rejects sound from the sides more effectively.
- Ideal for multi-source stage sound systems.
- It is used in theatre and TV production.
- May cause feedback if the monitor is directly behind.
- It is often used in reportage microphones.

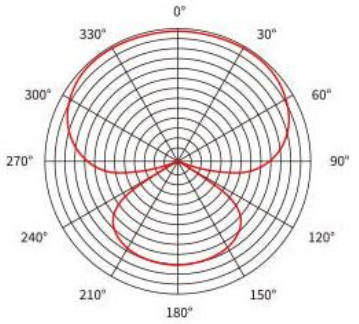


Hypercardioid microphone

- An even narrower beam of reception from the supercardioid.
- It has a larger rear lobe (about 180˚).
- It isolates the source from the ambient sound extremely well.
- Suitable for the precise capture of a single voice or instrument.
- Used in film and TV on a boom stick.
- It can be challenging to set up due to the rear lobe.
- Popular in situations where there is a lot of noise in the area.



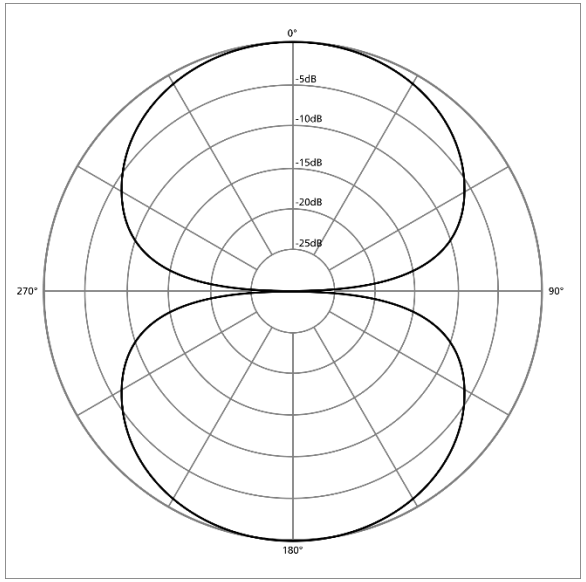
SUPERCARDIOID



HYPERCARDIOID

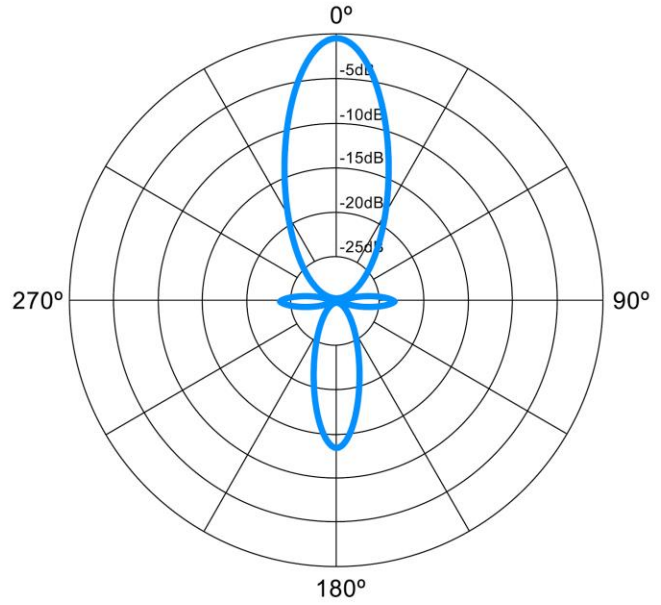
Figure-8 form

- Captures sound equally from the front and back.
- Completely rejects sound from the sides (90˚).
- Standard for ribbon microphones.
- Suitable for face-to-face interviews.
- Used in Blumlein stereo technique.
- It has a pronounced proximity effect.
- Can convey the natural acoustics of the space



Shotgun and lobar pattern

- The Shotgun microphone has an extremely directional polar pattern.
- Uses an interference tube to further discard from the sides.
- It uses the lobar pattern (narrow frontal beam) the most.
- Suitable for recording dialogue in a movie from a distance.
- Often mounted on a boom stick.
- It is also used as an on-camera microphone.



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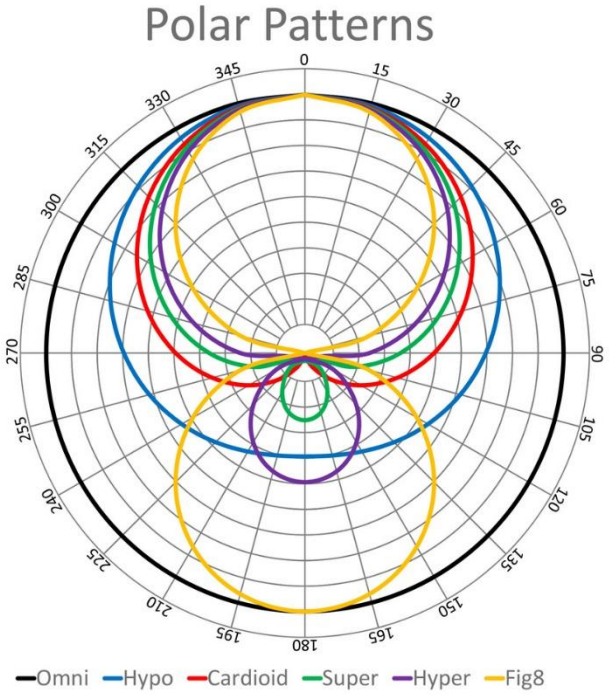
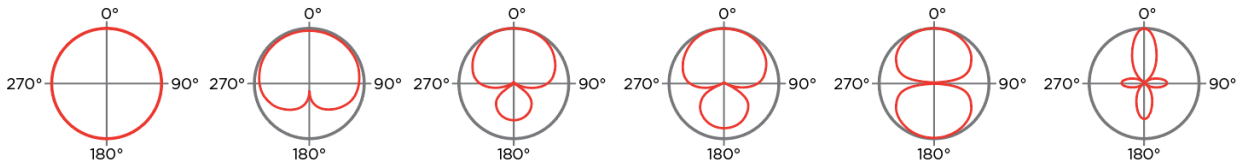
Multi-pattern microphones

- They allow the selection of multiple polar patterns.
- They use a flap or digital control.
- Suitable for studio condenser microphones.
- Flexible for different applications in one device.
- They enable stereo and experimental recording techniques.
- They are often used in studios for vocals and instruments.
- Some of them can contain multiple microphones inside (ceiling types?)



Comparison of polar patterns

- An omni-microphone is best for ambience, but it also captures noise.
- Cardioid is universal and most commonly used.
- Super and hypercardioid give better isolation.
- Figure-8 specializes in stereo and interviews.
- Shotgun is required in film production.
- Multi-pattern gives maximum flexibility.
- Each form has its place in the audio chain.



Pattern	Omnidirectional	Cardioid	Supercardioid	Hypercardioid	Bidirectional	Lobar (Shotgun)
Acceptance Angle [4]	n/a	130°	115°	105°	90°	35°
Maximum Rejection	n/a	180°	125°	110°	90°	30°
Distance Factor [5]	1.0	1.7	1.9	2.0	1.7	3.0

Microphone types by application:Lavalier microphones

- Small microphones that are attached to clothes.
- Discreet and suitable for TV shows and interviews.
- They most commonly use an electret capacitor capsule.
- They are available in wired and wireless versions.
- Ideal for allowing the speaker to move freely.
- Sensitive to clothing noise and touches.

Advantages and disadvantages of lavalier microphones

•Advantage: discreet and visually inconspicuous.

•Advantage: they allow freedom of movement.

•Advantage: great for interview shows and panels.

•Disadvantage : sensitive to the noise of clothing and wind.

•Disadvantage: they require good positioning for a natural tone.

•Disadvantage: sometimes produce unnatural sound due to proximity to the chest..

•They are often combined with boom microphones in film.

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Headset Microphones

- They are mounted around the head or behind the ear.
- They hold the microphone in a stable position in front of speaker's mouth.
- They are used in theatre, conferences and sports broadcasts.
- They ensure a consistent sound level regardless of movements.
- Discreet models have the color of skin to be invisible.
- Popular in live production and musical performances, sports.

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Shotgun Microphones

- Long microphones with interference tube.
- Extremely directional polar pattern (lobar).
- The most common choice for film dialogue.
- They are mounted on a boom stick or camera.
- Isolates sound well in noisy environments.
- It is also used in sports broadcasts.

Advantages and disadvantages of shotgun microphones

- Advantage: accurate capture of dialogue from a distance.
- Advantage: eliminates sounds from the sides.
- Advantage: it is also used as a backup on cameras.
- Disadvantage: requires precise routing.
- Disadvantage: captures reflections if the space is not treated.
- Disadvantage: long models can be tricky to operate.
- After all, they are the standard in the film industry.

Handheld microphones

- They are held in hand and used for reportage and vocals.
- Most commonly dynamic cardioid models.
- Robust and reliable in the field.
- They are often used with wireless transmitters.
- Standard for interviews and live events.
- They often have a built-in windscreen.

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Handheld microphones

- The large diaphragm provides rich and detailed sound
- Most commonly condenser models.
- Standard in music and radio studios.
- Great for vocals and acoustic instruments.
- They can have multiple polar patterns.
- Very sensitive to room acoustics.

Handheld microphones

- Small capsules deliver precise and linear sound.
- They are often used as overhead drum mics.
- Suitable for acoustic instruments (guitar, piano).
- They have a wider frequency response and a better transient response.
- They emphasize the color of the sound less than a large diaphragm microphone.
- Popular in orchestral and choral recordings.

Boundary microphones

- Flat microphones that are placed on a table or floor.
- They use reflections for a more natural sound.
- Often omni or cardioid pattern.
- Suitable for conferences and panels.
- They are also used in theaters and sports halls.
- Discreet and undetectable on stage.

On-camera microphones (Top-mount)

- They are mounted directly on the camera.
- Typically shotgun type with a cardioid/lobar pattern.
- Used to back up audio or snapshots.
- They are connected with a mini-jack or XLR adapter.
- Compact and easy to carry.
- They are not a substitute for boom microphones in film.

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Application in TV production

- Lavalier microphones for hosts and guests.
- Shotgun microphones for field interviews.
- Handheld microphones for live reporters.
- Boundary microphones for discussion panels.
- Studio condensers for studio emissions.
- Wireless free movement systems.
- On-camera microphones as additional protection.

- **The best results are achieved by combining types.**

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Application in film production

•hotgun microphones on boom sticks for dialogue.

•Lavalier hidden under the actors' clothes.

•Binaural for special effects.

•Contact microphones for special sounds.

•Stamps and recorders for mobile recording.

•A combination of multiple types for realistic sound.

•Standard in every film crew.

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Application in music

- Large diaphragm vocal capacitors.
- Small diaphragm for acoustic instruments.
- Dynamic microphones for drums and amplifiers.
- Ribbon microphones for guitar amplifiers and brass instruments.
- Stereo couples for orchestra and choir.
- Lavalier and headset for musical theatre.
- Each instrument has an optimal microphone type.

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Applications in conferences and theatre

- Lavalier microphones for lecturers.
- Headset microphones for actors in plays.
- Boundary microphones on stage.
- Handheld microphones for panel participants.
- Ceiling for conference rooms for automation.
- Goseneck microphones for each participant.
- Studio condensers for choir sound system.
- Integration of microphones with the venue’s sound system.
- The need for good monitoring and feedback control.

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Combining microphones in practice

- The best results are achieved by combining types.
- Lavalier for stable dialogue + shotgun for naturalness.
- Studio voice microphone + small instrument condenser.
- Interview handheld microphone + on-camera backup.
- Ambient + binaural for an immersive experience.
- A field recorder with multiple inputs for parallel recording.
- The combination depends on budget and production.

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Wired and wireless microphones: Wired microphones

- They are connected directly via XLR or TRS cable.
- Stable and reliable connection without RF interference.
- They are not dependent on batteries or wireless transmitters.
- Lower price compared to wireless systems.
- They are used in studios and on stage where movement is not restricted.
- Cable length may be a limiting factor.
- Standard for recording music and in controlled spaces.

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Advantages and disadvantages of wired microphones

- Advantage: reliable and high-quality audio transmission.
- Advantage: no RF interference and interference.
- Advantage: lower price and easy maintenance.
- Disadvantage: limited freedom of movement.
- Disadvantage: risk of tripping over cables.
- Disadvantage: cables require regular maintenance.
- Suitable for static sound sources.

Wireless microphones

- They transmit the signal via radio frequency (RF).
- They allow the freedom of movement of contractors and reporters.
- They are used in TV, film, theatre and concerts.
- They consist of a transmitter (TX) and a receiver (RX).
- Most often they operate in the UHF/VHF and 2.4 GHz range.
- Modern systems use digital transmission.

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Advantages and disadvantages of wireless microphones

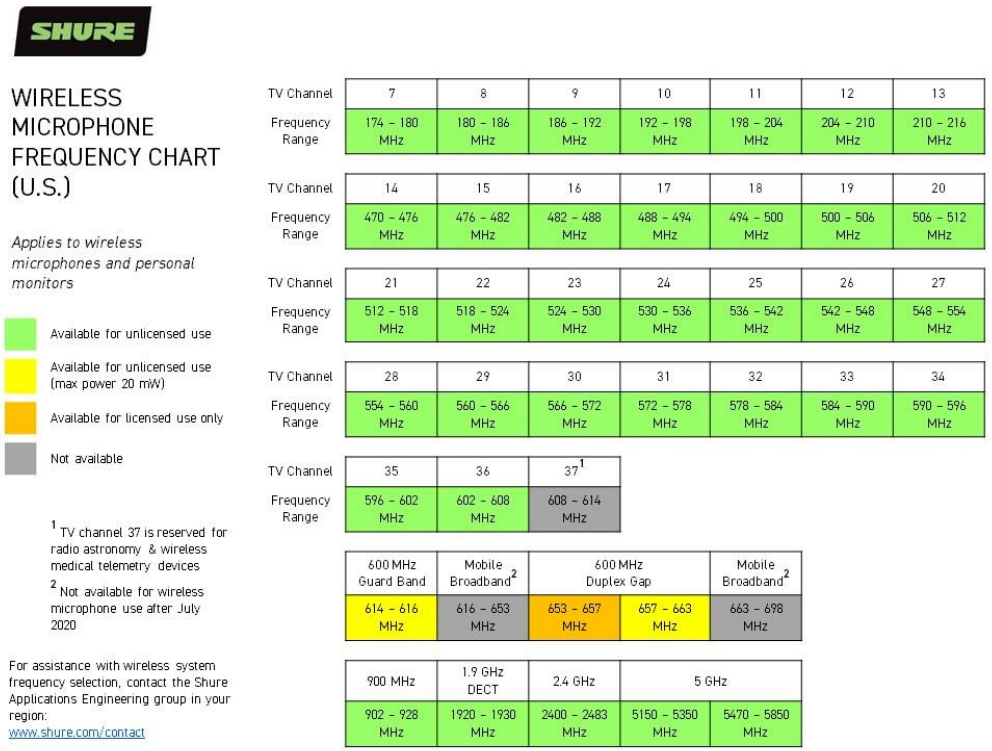
- Advantage: freedom of movement for the user.
- Advantage: discreet appearance (lavalier, headset).
- Advantage: practical solution for the terrain and scene.
- Disadvantage: RF interference can degrade the signal.
- Disadvantage: need for batteries or charging.
- Disadvantage: more expensive than wired microphones.
- They require frequency planning in larger systems.

Digital wireless systems

- They transmit the signal in digital format (24-bit/48 kHz).
- They have a wider dynamic range and lower noise.
- They can operate in unregulated ranges (2.4 GHz).
- They provide encryption to protect the signal.
- Flexible for automatic free-frequency scanning.
- Higher latency than analog systems.

Frequency bands for wireless microphones

- UHF band (470–694 MHz) most commonly used in broadcast.
- 2.4 GHz systems popular with smaller kits.
- 5.8 GHz is used in some modern systems.
- It is necessary to monitor the regulations in each country.
- Digital systems often have automatic frequency scanning.
- Large systems require multi-channel coordination.
- RF management is an essential part of imaging preparation.



SHURE

WIRELESS MICROPHONE FREQUENCY CHART (U.S.)

Applies to wireless microphones and personal monitors

- Available for unlicensed use
- Available for unlicensed use (max power 20 mW)
- Available for licensed use only
- Not available

[1] TV channel 37 is reserved for radio astronomy & wireless medical telemetry devices

[2] Not available for wireless microphone use after July 2020

For assistance with wireless system frequency selection, contact the Shure Applications Engineering group in your region:
www.shure.com/contact

TV Channel	7	8	9	10	11	12	13
Frequency Range	174 – 180 MHz	180 – 186 MHz	186 – 192 MHz	192 – 198 MHz	198 – 204 MHz	204 – 210 MHz	210 – 216 MHz

TV Channel	14	15	16	17	18	19	20
Frequency Range	470 – 476 MHz	476 – 482 MHz	482 – 488 MHz	488 – 494 MHz	494 – 500 MHz	500 – 506 MHz	506 – 512 MHz

TV Channel	21	22	23	24	25	26	27
Frequency Range	512 – 518 MHz	518 – 524 MHz	524 – 530 MHz	530 – 536 MHz	536 – 542 MHz	542 – 548 MHz	548 – 554 MHz

TV Channel	28	29	30	31	32	33	34
Frequency Range	554 – 560 MHz	560 – 566 MHz	566 – 572 MHz	572 – 578 MHz	578 – 584 MHz	584 – 590 MHz	590 – 596 MHz

TV Channel	35	36	37[1]
Frequency Range	596 – 602 MHz	602 – 608 MHz	608 – 614 MHz

600 MHz Guard Band	Mobile Broadband[2]	600 MHz Duplex Gap		Mobile Broadband[2]
614 – 616 MHz	616 – 653 MHz	653 – 657 MHz	657 – 663 MHz	663 – 698 MHz

900 MHz	1.9 GHz DECT	2.4 GHz	5 GHz	
902 – 928 MHz	1920 – 1930 MHz	2400 – 2483 MHz	5150 – 5350 MHz	5470 – 5850 MHz

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Diversity receivers

- They use two antennas for more stable signal reception.
- They prevent losses due to RF reflections and fading.
- There are True Diversity and Antenna Diversity systems.
- Standard in professional wireless systems.
- Mandatory in TV studios and at stage events.
- They reduce the risk of signal interruption.
- They increase reliability in demanding conditions.

Batteries and power supply

- Wireless transmitters use AA batteries or Li-Ion rechargeable batteries.
- Modern systems have battery life indicators.
- Professional systems use rechargeable modules.
- Battery management is key in live production.
- Docking stations for charging are used in the studios.
- Battery backup in the field is always provided.
- Poor battery may cause signal loss.

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Accessories

- The microphone rarely works on its own, it needs additional equipment.
- The equipment provides stability, protection and better sound quality.
- Brackets, filters and wind protection are most commonly used.
- Portable recorders are also used for field work.
- Each production requires its own set of accessories.
- Equipment is just as important as the microphone itself.
- The investment in accessories extends the life of the microphone.

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Shock mount

- Brackets that prevent vibrations from being transferred to the microphone.
- They use rubber bands or elastic systems.
- Standard for studio condenser microphones.
- Elimination of rack impacts and floor vibration.
- Mandatory in a professional studio environment.
- They improve the cleanliness of the recorded sound.

Shock mount

- It is used to eliminate floaters (P, B sounds).
- Most often mesh or foam placed in front of the microphone.
- Prevents moisture and saliva from entering the microphone.
- Mandatory vocal recording equipment.
- Improves the intelligibility of speech and singing.
- Available as circular filters or integrated in a stand.
- Cheap, yet significantly improves quality.

Windscreen (sponge protection)

- Foam that is placed over the microphone.
- Reduces wind noise when working outdoors.
- Prevents floating sounds with handheld microphones.
- Mandatory in reporting situations.
- It comes in different shapes and colors.
- Does not significantly change the frequency response.
- Deadcat, advanced wind protection for field work.

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Boom sticks

- Extended mounts for shotgun microphones.
- They allow you to shoot outside the camera frame.
- They are made of carbon or aluminum.
- Lightweight but sturdy for long-lasting handling.
- Often integrated with cables inside.
- Boom operator is a specialized function on a set.

Tripods & Mounts

- They are used for stable microphone placement.
- There are standing, floor and table tripods.
- Some models have telescopic arms.
- Study work requires stable and heavy racks.
- Fieldwork requires lightweight and foldable models.
- The holders must be compatible with the shock mount.

Field recorders

- Portable recorders with integrated microphones.
- They allow recording outside the studio.
- They use SD cards to save recordings.
- They have multiple inputs for external microphone connection.
- Popular in documentary and field shooting.
- Examples: Zoom H6, Tascam DR-40X.
- Standard piece of film toner equipment.

Cables and connectors

- XLR is the standard in the professional audio industry.
- TRS and mini-jack are used in smaller systems.
- Cables must be balanced to avoid noise.
- Long-term operation requires quality cables and connectors.
- A bad cable can ruin the quality and reliability of the system.
- The connectors are regularly maintained and cleaned.
- Standard: Neutrik XLR connectors.

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Audio Signal Types – Overview

- Microphone signal — very low level and requires preamplification.
- Line signal — power and level that is standard for the devices.
- Instrument signal — level between microphone and line.
- Hi-Z signal — a high resistance signal typical for guitars.
- Digital audio signal — encoded (e.g. AES/EBU, S/PDIF, ADAT).
- Balanced and unbalanced analog signals.
- Potential (PE) signal — grounding in the audio system.

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Microphone signal

- The microphone signal is weak (microphone level) and often in millivolts (mV).
- The balanced microphone signal uses a three-pin XLR connector.
- Condenser microphones require phantom power (+48V).
- This signal must pass through the mic preamp to become in-line.
- Noise-sensitive, so balanced cables are used.
- Microphone cables are balanced to reduce noise.
- Different microphones have different output sensitivities
- Level: very weak, typically from –60 dBu to –40 dBu (0.8–7 mV).

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Line signal

- Level: much stronger, typically about **+4 dBu (1.23 V RMS, professional standard)**.
- In consumer electronics: **–10 dBV (0.316 V RMS)**.
- Used to connect mixers, recorders, processors, amplifiers.
- It can be balanced (XLR/TRS) or unbalanced (RCA).
- It does not require much reinforcement, but only processing and routing.
- The most common signal level in the audio industry.

Instrument signal (guitar, bass, keyboard)

- Level: between microphone and line, typically around **–20 dBu (77 mV)**.
- Guitars and bass guitars use **Hi-Z (high impedance, ~1 MΩ)**.
- They are sensitive to losses and noise on longer cables.
- A **DI box** is required to convert to a balanced signal.
- Keyboards often give in-line or close to line level.
- Standard connector: **TS (¼” mono jack)**.

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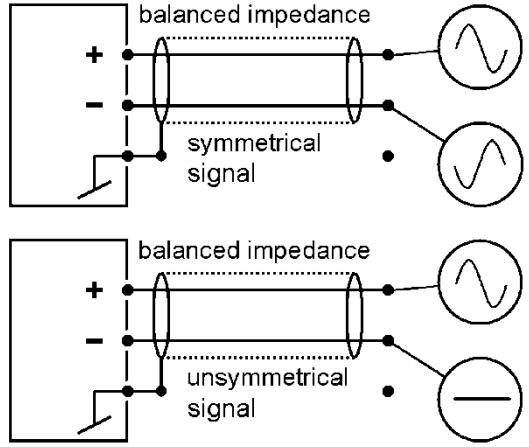
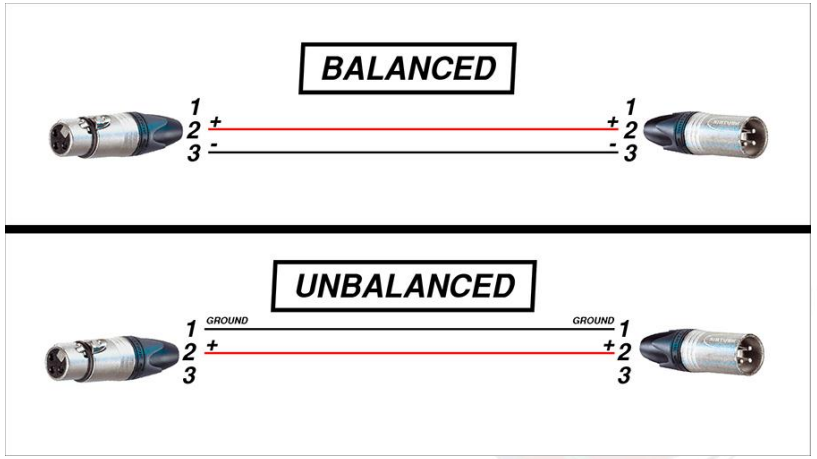
Hi-Z signals

- **Hi-Z (High Impedance)** typically indicates an impedance of **500 kΩ – 1 MΩ**.
- It is most commonly used in guitars and old instruments.
- Suitable for entry into guitar amplifiers.
- If it connects directly to the line input – it loses high frequencies and gets noise.
- DI box lowers impedance and balances the signal.
- In studios, Hi-Z input is used on specialized interfaces.

Balanced signals

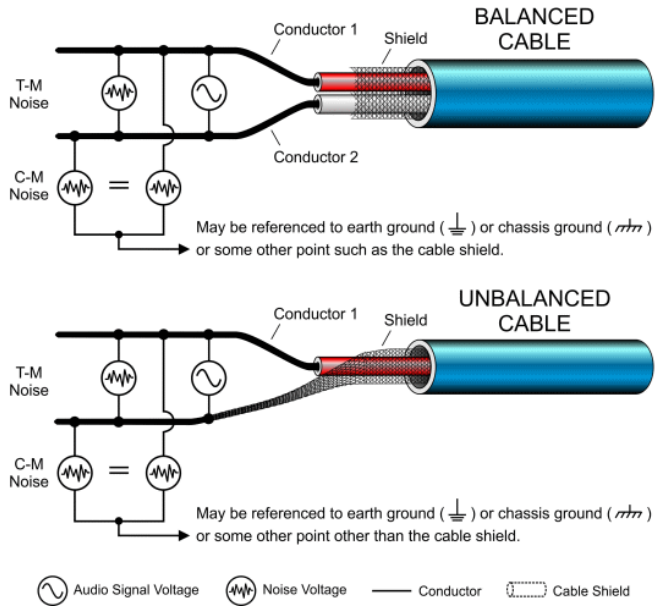
- They use **two conductors + mass**: signal (+), inversion (–), mass.
- Operating voltage: same as line voltage, but with **reduced interference**.
- Noise is cancelled (common-mode rejection).
- Standard for **professional mixers and long cables**.
- Typical connectors: **XLR, TRS (jack stereo ¼”)**.
- It enables transmission even over 100 m without loss of quality.
- They are used for both microphone and line signals.





Unbalanced signals

- Only use **signal + mass**.
- Typical connectors: **TS (mono jack), RCA**.
- Short cable lengths (<5 m) to avoid noise.
- Standard in consumer electronics (CD players, DVDs, laptops).
- Suitable for home systems, but not for professional applications.
- Easily introduce noise and RF interference.
- Signal level: depends on whether it is in-line (–10 dBV) or instrument-level.



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Digital audio signals

- They transmit audio in **digital form (0/1)**.
- Signal levels depend on the standard:
- **AES/EBU**: balanced XLR, 110 Ω impedance.
- **S/PDIF**: coaxial RCA (0.5 Vpp) or optical Toslink.
- **ADAT**: optical multichannel transmission.
- **MADI**: up to 64 channels via coaxial or fiber optic cable.
- Immune to analog interference, but dependent on clock synchronization.
- Standard in modern studios and broadcast systems.

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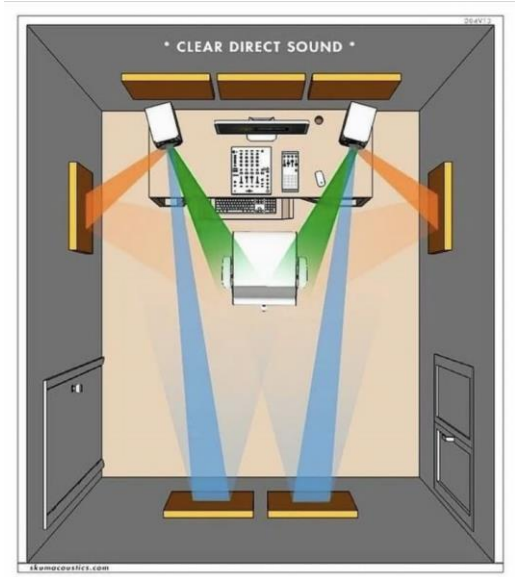
Comparison of signal levels

- **Microphone level**: –60 dBu to –40 dBu (0.8–7 mV).
- **Instrument level**: approx. –20 dBu (~77 mV).
- **Line level (professional)**: +4 dBu (1.23 V RMS).
- **Line level (consumer)**: –10 dBV (0.316 V RMS).
- **Digital signals**: depend on the standard, whether they transmit data, not voltage.
- **Hi-Z input**: high impedance, used for instruments.
- Correct signal alignment is the key to clear sound.

Role of monitoring

- Monitoring allows the sound engineer and the performer to hear the sound in real time.
- Helps with quality control and balance.
- There is monitoring via headphones and studio speakers.
- In a live environment, monitoring is crucial for contractors.
- Poor monitoring makes mixing and execution difficult.
- Professional systems use a combination of both types.
- Monitoring is an integral part of any audio production.



Role of monitoring

- They allow insulation from external sound.
- They are used for precise control during recording.
- There are open-back and closed-back models.
- Closed-back models are better for recording vocals.
- Open-back give a more natural sound for the mix.
- Headphones are indispensable for individual monitoring.

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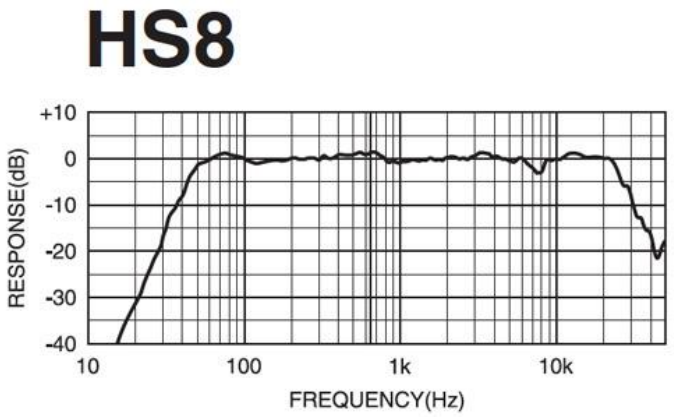
In-ear monitors (IEM)

- They are used by live performers on stage.
- They provide an individual mix for each musician.
- Isolation from stage noise and feedback.
- Wireless IEM systems allow for freedom of movement.
- They reduce the risk of hearing damage in noisy environments.
- Popular with singers and instrumentalists at concerts.

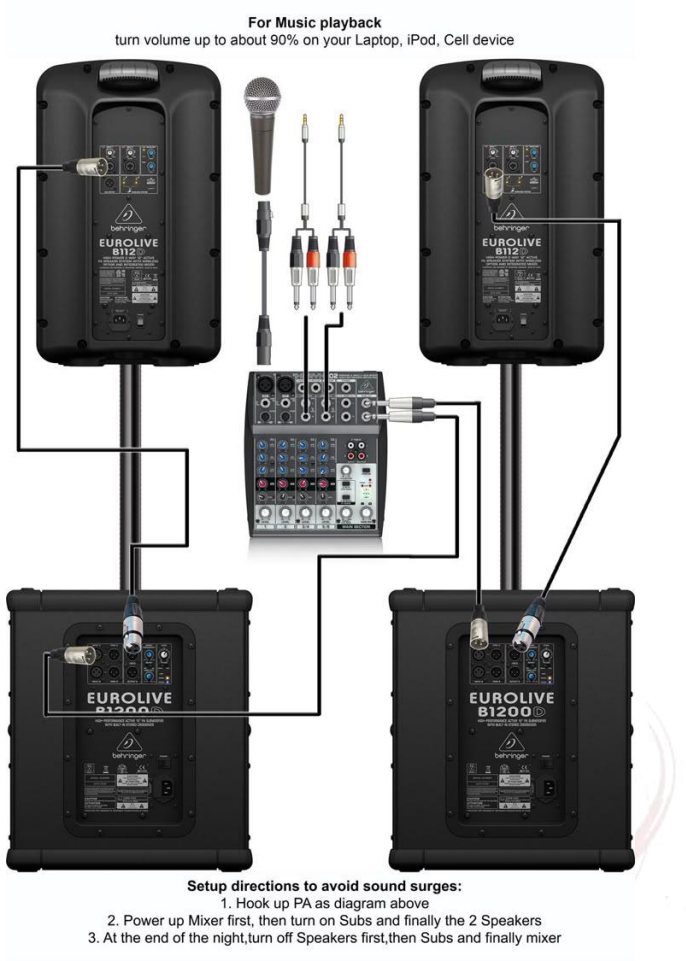
Studio monitor speakers

- Speakers with linear frequency response.
- They allow faithful reproduction of the recorded material.
- They are used in mixing and mastering.
- Close monitoring (nearfield) reduces the impact of the room.
- Further monitoring is used in larger studies.
- Placement in an acoustically treated room is mandatory.



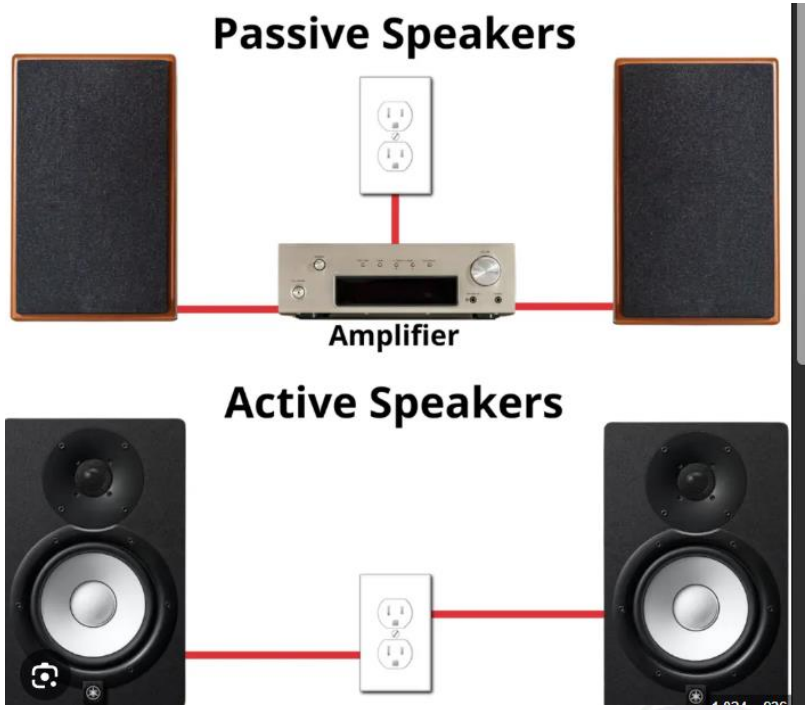
PA (Public Address) Systems

- PA systems are used for amplifying sound in spaces and events.
- They deliver speech, music, and announcements to audiences.
- They consist of a microphone, mixer, amplifier and speaker.
- They are used in concerts, sports events, conferences.
- They include main (FOH) speakers, monitors and subwoofers.
- Professional PA systems are modular and scalable.
- There are passive and active PA systems.



Active vs Passive Speakers

- **Active speakers** have a built-in amplifier.
- They are directly connected to the mixer or audio source.
- Easy to install and suitable for mobile use.
- **Passive speakers** require an external amplifier.
- More flexible for large systems and installations.
- Passive systems are used in professional sound systems.
- Active ones are popular in smaller halls and mobile setups.

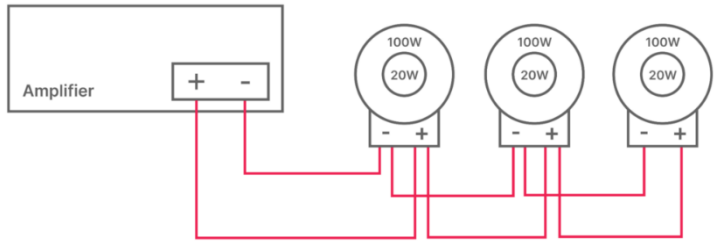


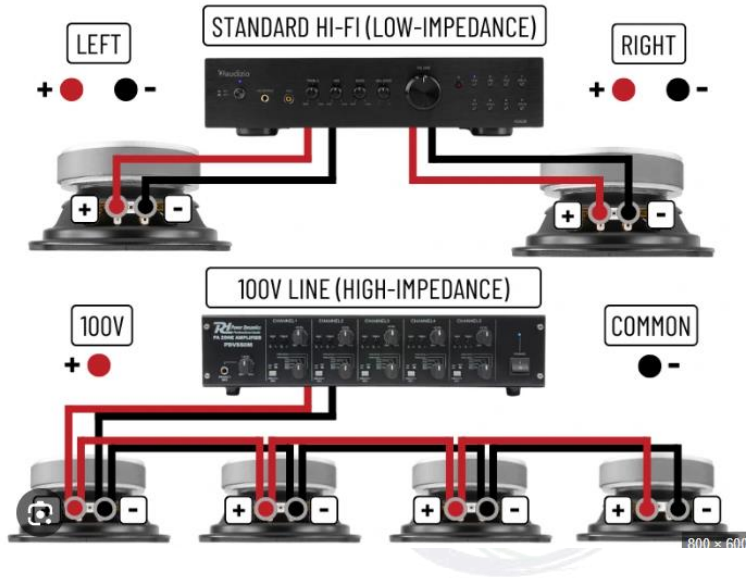
Line Array

- Line array is a set of speakers placed vertically.
- It is used for large concerts and halls.
- Distributes sound evenly over long distances.
- It can be scaled depending on the size of the event.
- It must include subwoofers for low frequencies.
- Requires DSP processors for optimization.

100V systems

- 100V systems are used in public and commercial spaces.
- They enable the distribution of sound over long distances.
- Each speaker has a built-in transformer.
- The connection is serial or parallel, without signal losses.
- Most often for the sound system of schools, shopping malls, factories.
- They allow multiple speakers to be connected at the same time.
- Standard in PA installations.





Monitoring in TV and Film

- Sound engineers use headphones for monitoring during recording.
- Studio monitors are used for control in post-production.
- IEM systems are used by the stage manager.
- In film production, monitoring must be unobtrusive.
- Real-time monitoring prevents recording errors.
- Broadcast requires multi-point monitoring at the same time.
- High-quality speakers are used in the control rooms.

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Field monitoring

- Field sound engineers use headphones resistant to external noise.
- Portable recorders have an integrated monitoring output.
- IEM systems enable wireless monitoring.
- Speakers are used less often due to mobility.
- Monitoring must be reliable in different conditions.
- Professional models have a high level of insulation.

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Role of the audio mixer

- The mixer is the central sound control device.
- Allows you to combine multiple microphones and sources.
- Controls the levels, tone and panorama of the signal.
- There are analog and digital mixers.
- In TV production, the mixer is in the control room, and monitoring is handled by the sound engineer.
- Mixers are mandatory in every professional production.
- The role of the sound engineer is just as important as the director of the picture.

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Analog Mixers

- Traditional devices with physical faders and potentiometers.
- The signal is processed entirely through analog means.
- Reliable and intuitive to use.
- Limited options compared to digital consoles.
- Often used in smaller studios and sound reinforcement setups.
- Still popular for its sonic character.

Digital mixers

- They allow digital signal processing.
- They have integrated effects and processors.
- Support scenes and stored settings.
- Flexible for complex productions.
- They allow remote control via tablets.
- Standard in modern TV and concert productions.

Behringer X32

- Behringer X32 is a popular digital audio mixer with 32 inputs and 16 outputs.
- It combines digital functions, effects and network connectivity.
- It is often used in concerts, churches, schools and studios.
- It has an intuitive display and fader controls, suitable for live operation.
- Supports digital protocols such as AES50 and USB interface.
- It is useful for mixing multiple microphones and instruments in real time.

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Behringer X32

- 32 expandable input channels via AES50/AES.
- 16 main outputs, including measurement section (monitor) and effect senders.
- Internal effects and processors (EQ, compressors, reverbs).
- USB interface for recording and playback up to 32 lanes.
- Network connection (Ethernet) and support for digital protocols.
- Scenes and saving settings for different events.
- Remote control via apps on mobile devices.

Behringer X32

- Concert and tour production console where live audio is required.
- Used in studios for recording live performances and live DJ sets via tablets.
- In live stream productions where a digital interface and software integration are required.
- In television studios when flexibility and control of multiple channels is required.
- In conferences and events where speech and musical elements are combined.
- As a central mixer connected to digital systems (e.g. Dante, AES50).

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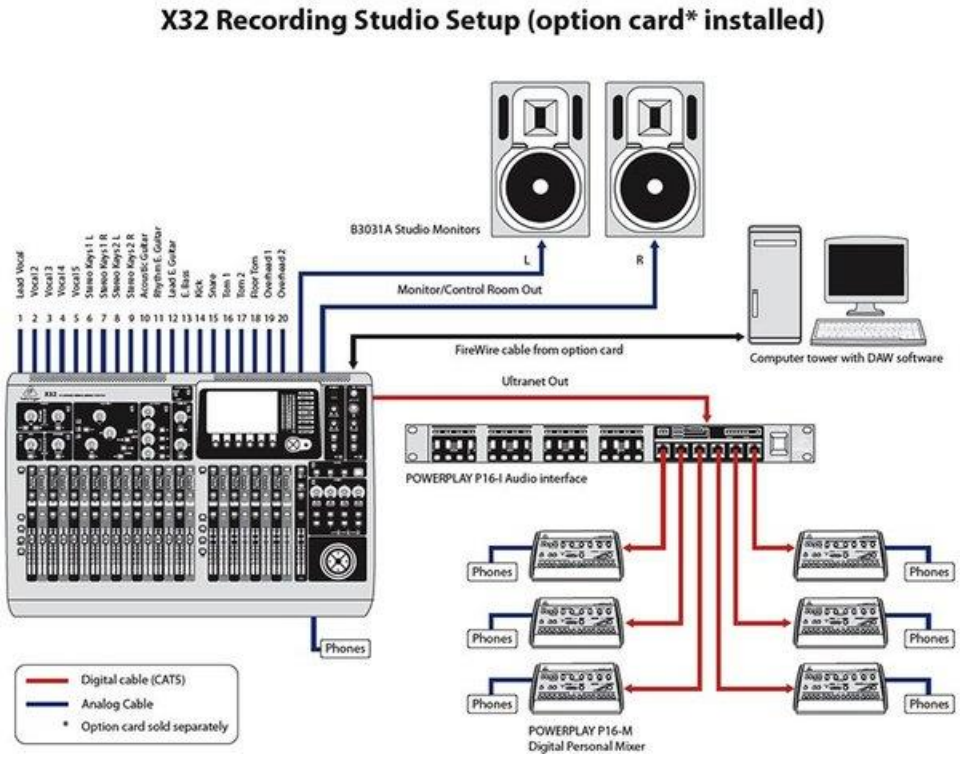
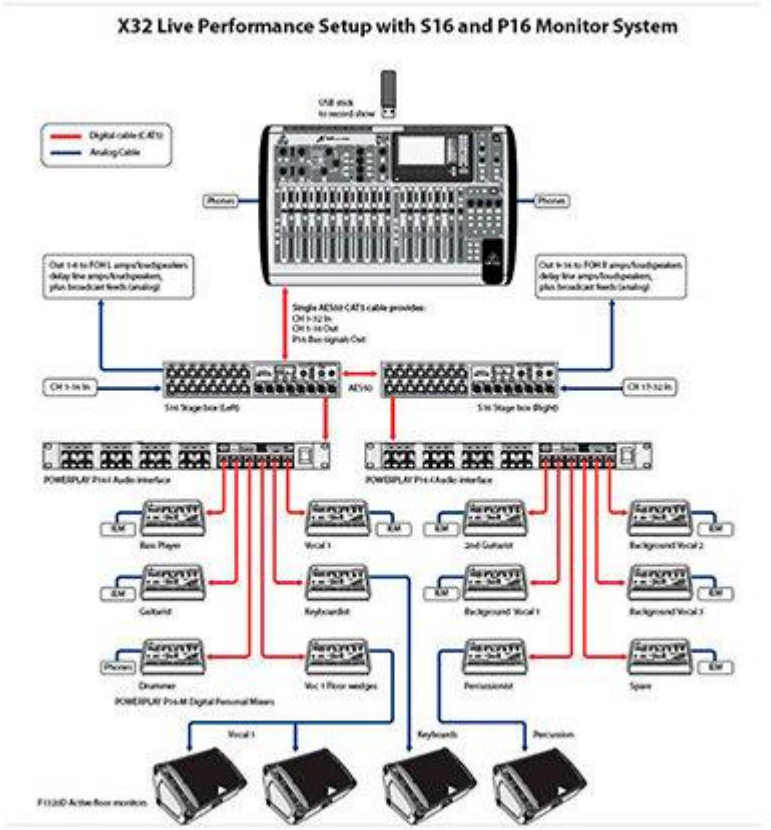
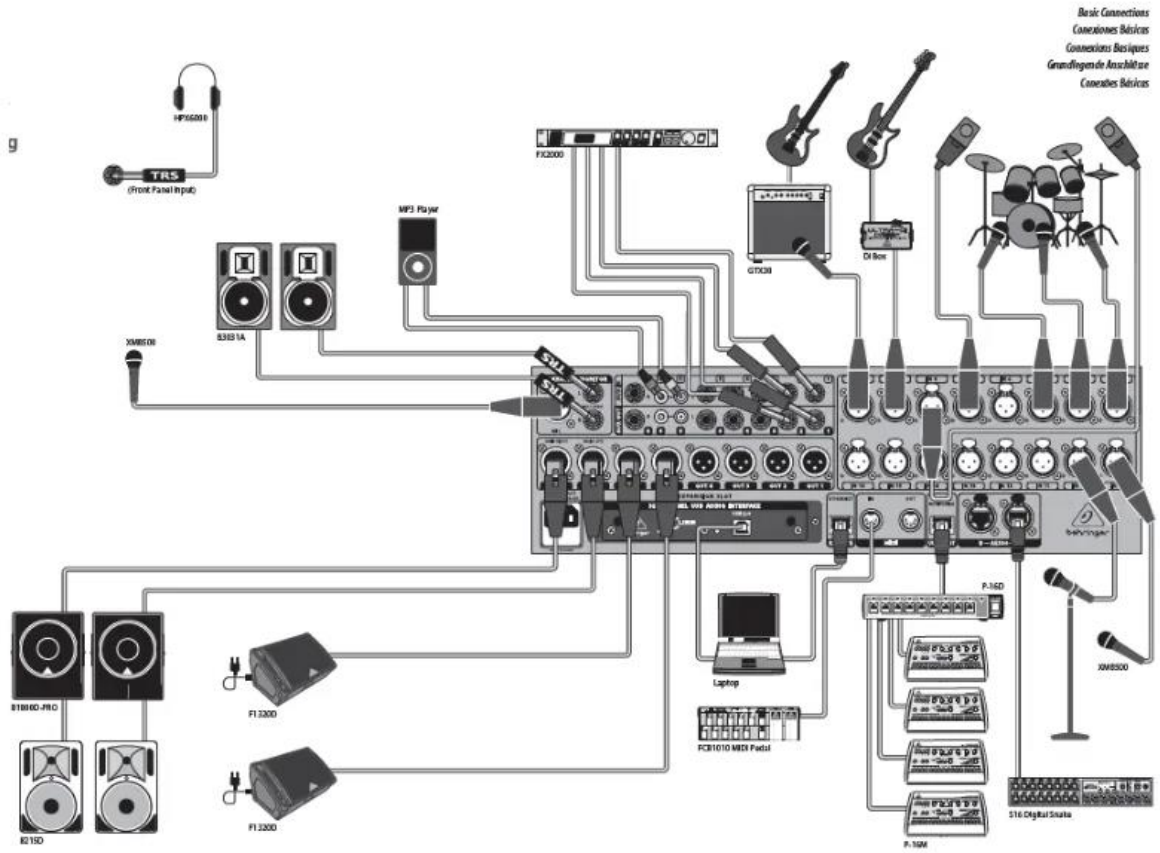
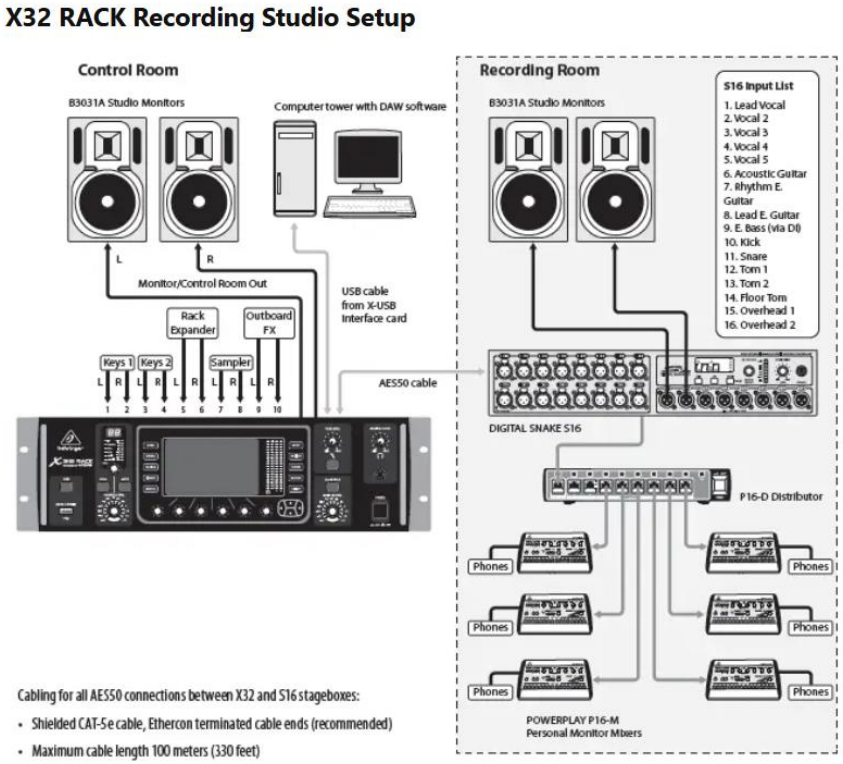
Behringer X32



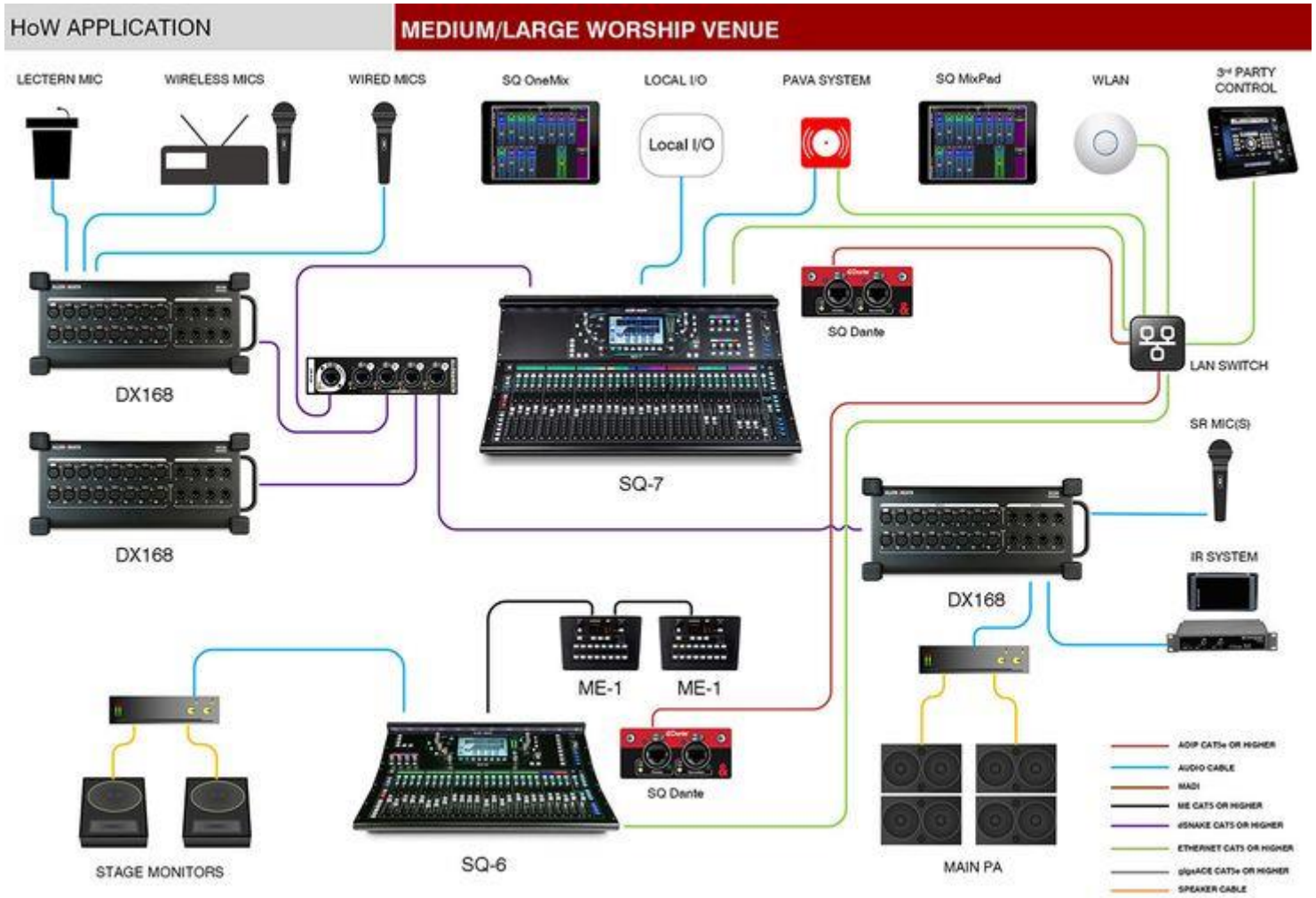


Behringer X32





Example


HoW APPLICATION
MEDIUM/LARGE WORSHIP VENUE
LECTERN MIC
WIRELESS MICS
WIRED MICS
SQ OneMix
LOCAL I/O
PAVA SYSTEM
SQ MixPad
WLAN
3rd PARTY CONTROL
Local I/O
DX168
DX168
SQ-7
SQ Dante
LAN SWITCH
SR MIC(S)
IR SYSTEM
DX168
ME-1
ME-1
SQ Dante
SQ-6
STAGE MONITORS
MAIN PA
AOIP CAT5e OR HIGHER
AUDIO CABLE
MADI
ME CAT5 OR HIGHER
dSNAKE CAT5 OR HIGHER
ETHERNET CAT5 OR HIGHER
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SPEAKER CABLE

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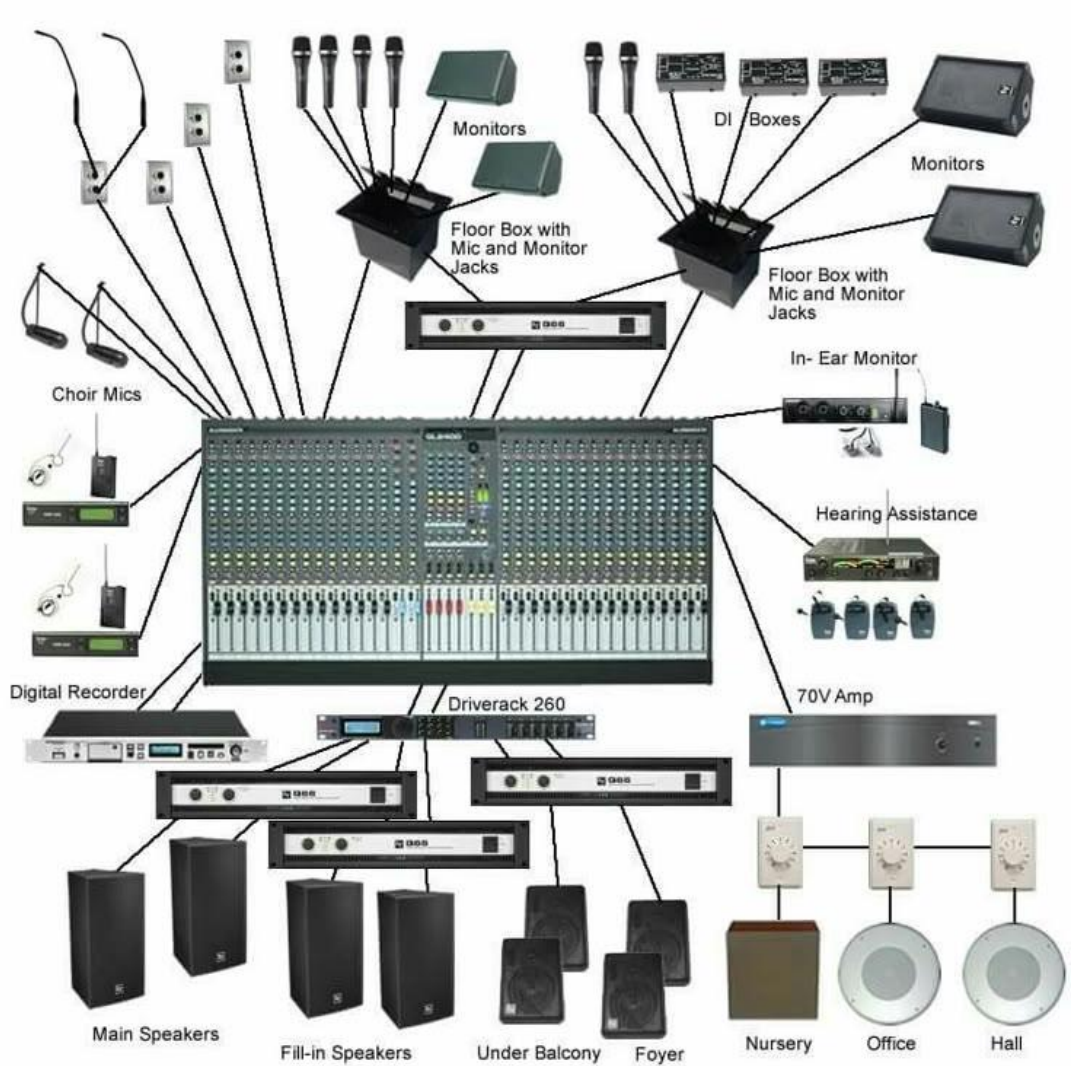
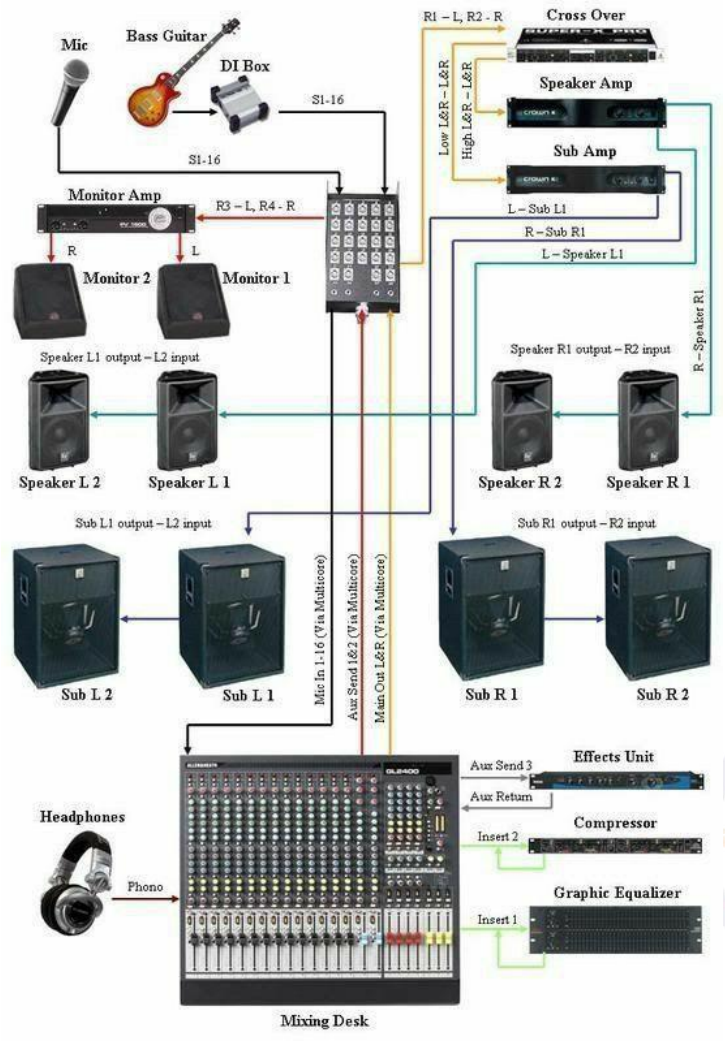
Example





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Questions & Answers

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