Audio Systems

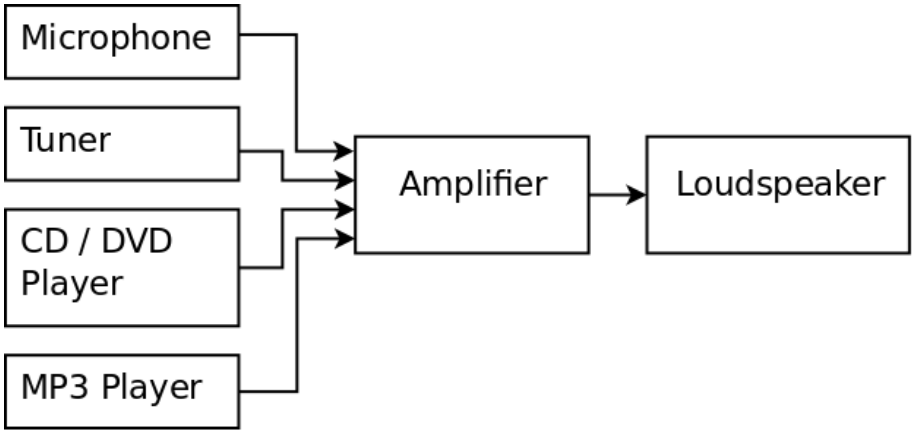
Introduction

A HiFi system is an audio system used in the home. There may be several sources of music but only **one** source is selected, amplified and played through the loudspeakers.

An audio or amplifier system is used in venues and concerts. Such systems are also known as P.A. (Public Address) systems. In an amplifier system **multiple** music or audio sources are mixed together and the result is amplified and played through the loudspeakers.

Introduction to HiFi Systems

A domestic HiFi or Audio system is made from several separate sub-systems.



There are several different **input** subsystems that all connect directly to the amplifier.

The amplifier is the **process** sub-system.

The **output** sub-system is the loudspeaker.

Components of a typical HiFi

The **Microphone** is used to record sounds or voices. A microphone is an analogue device. A microphone is often connected to a recording device.

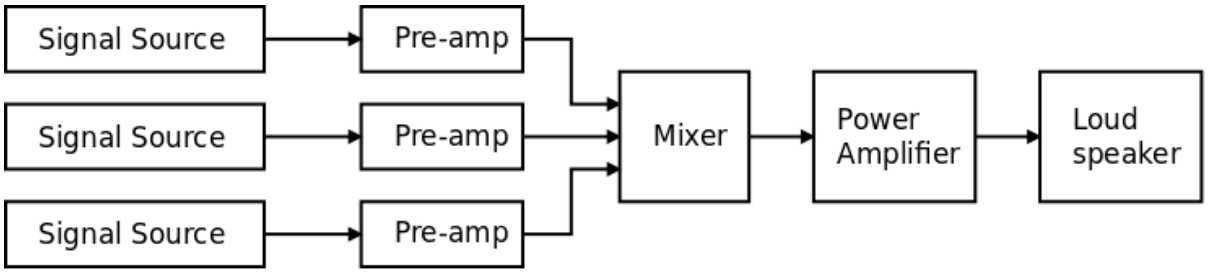
A **Tuner** is more commonly known as a radio. A tuner uses an aerial to receive high frequency radio waves. The selected carrier wave is demodulated to produce an analogue audio signal that can be amplified.

An **MP3 Player**, a **CD Player** and a **DVD Player** are all digital devices. Audio signals are stored as digital data and then converted back into analogue signals that can be amplified.

An **Amplifier** increases the voltage of the input signal and provides current to drive the loudspeakers. The amplifier increases the power available and is sometimes called a power amplifier. The amplifier sub-system also includes the volume control and way to select what to listen to as well as other functions such as tone controls.

The **Loudspeaker** converts electrical signals into sound. It is an example of an output transducer.

Introduction to Audio Amplifier (P.A.) Systems



An audio amplifier system includes several signal (audio) sources.

Each audio source goes through a pre-amplifier that adjusts the volume level and equalisation.

All of the signals are mixed together in the mixer circuit.

A power amplifier amplifies the mixed signals and increases the output voltage and current to drive the loudspeaker system.

Components of a typical Amplifier system

The **signal source** includes microphones, instruments such as guitars and keyboards and audio sources such as CD players.

A **pre-amplifier** (pre-amp) changes the voltage level of the signal sources and may change the tone of the audio signal (equalisation). Pre-amps are often based around **inverting voltage amplifier** circuits.

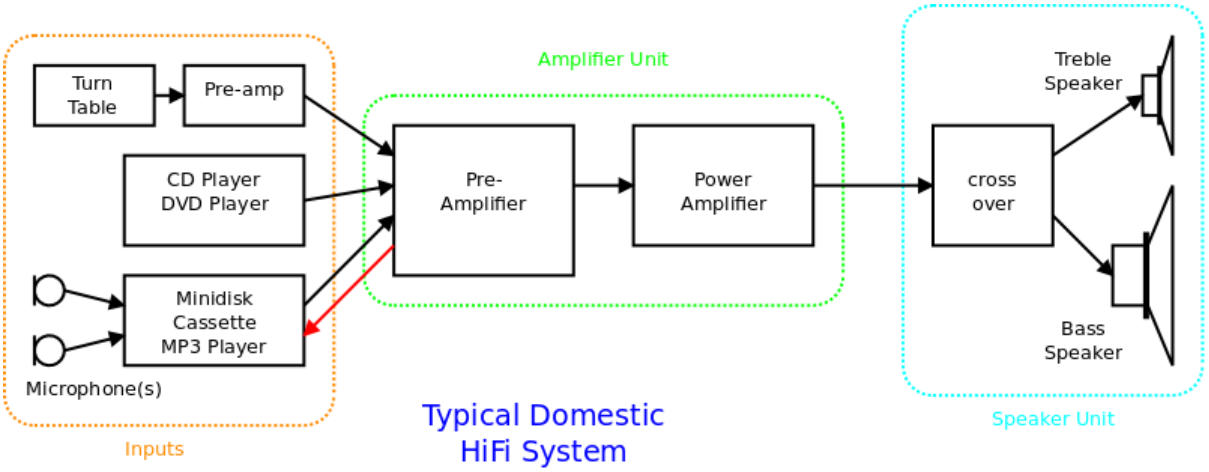
The **mixer** circuit combines all the different signal sources together to produce a single signal. Mixer circuits are based around **summing amplifiers**.

An **Amplifier** increases the voltage of the input signal and provides current to drive the loudspeakers. The amplifier increases the power available and is sometimes called a power amplifier.

The **Loudspeaker** system converts electrical signals into sound. It is an example of an output transducer.

HiFi systems in more detail

A typical system diagram for a domestic audio system or HiFi (**Hi**gh **Fi**delity) system is shown.



It is important to realise that all of the inputs feed into the amplifier and a selector decides which one to use.

As seen, more simplistic system diagrams combine the pre-amplifier and amplifier into one amplifier block and combine the different speakers and their cross-over into a simple speaker block.

HiFi Components in more detail

Inputs: The microphones, cassette player, CD player, DVD player, turntable (with pre-amp), Radio Tuner, Minidisk player and MP3 player are all inputs. The music is encoded on some media and is converted to electrical signals by the various players. These will be considered in more detail later

Process: The amplifiers process the electrical signals from the various sources. The pre-amp adapts the signal by altering the tonal balance (equalization), selecting which input to use, providing volume and balance controls, and often powering a headphone socket. The amplifier increases the output power (both voltage and current)

Outputs: The speakers translate the electrical signals from the amplifier into sound signals. The bass speaker is the bigger speaker and handles low frequencies, the smaller speakers handle the higher frequencies. The passive crossover splits the signal into its various frequencies so that the correct signals are sent to the appropriate speaker

Input Devices in more detail

A typical Microphone produces an output voltage of 10 mV.

A microphone consists of a diaphragm that is free to move due to varying sound pressure levels. The diaphragm carries a coil which, when moved in a magnetic field, produces an emf. The output of a microphone is usually passed through a small signal transformer to provide impedance matching and balanced line functionality. Professional microphones may be 'active' meaning that they require a power supply (battery or external) and provide some signal amplification and/or conditioning. There are other types of microphone available that produce a higher output. In general, however, the output from a microphone is pretty small and will need to be amplified.

A **Radio Tuner** (or just Tuner) uses an aerial to pick up very high frequency radio waves at frequencies greater than 300 kHz.

Different radio stations transmit their own carrier waves at one particular frequency and these radio carrier waves are modulated to carry information. The tuner selects one particular frequency of carrier wave and demodulates the carrier wave to produce an audio signal that can be amplified. In domestic audio systems there are two main types of radio tuners - A.M. and F.M.

An **MP3 Player** typically produces an output voltage of 1.0 V rms.

An MP3 player stores the signal digitally but, unlike all the other sources listed, uses a solid state memory device as the storage media - a memory chip. MP3 music files are compressed in a ratio of about 12:1 and each average length track is about 4 Mb in total ... on a 128 Mb storage media about 32 tracks can be stored which is about 2CD's worth. The advantage of using non mechanical media is that the MP3 player is virtually bomb proof and so using it in the car etc poses no problems. Music files can be downloaded to the media from a computer and accessed in any order. The major disadvantage is that MP3 quality is not as good as music recorded to CD. MP3 players as stand alone devices that carried your music were universally popular until the modern smartphone came along and pretty well took over. The iconic MP3 player is Apple's iPod which actually used a miniature hard-drive to store the data.

A **Compact Disk** (CD) and **DVD Player** typically produces an output voltage of 1.0 V rms.

CD (and DVD) players read digital information (not only music) from a plastic disk. The data is stored as pits and bumps on the reflective surface of the disk and the data is read using a laser (to achieve the fine focus necessary). Because the storage media is optical it does not suffer from the effects of external magnetic fields like minidisk or cassette.

The CD is tolerant of scratches and dirt and so is fairly robust but the laser head is easily knocked out of alignment by use in a personal player or car etc. Modern players have a buffer that reads ahead a few seconds so that the effect of jolting the device is minimised. Although the disks are recordable, this is not as practical in real time and so the CD player is not as versatile as the minidisk. The disks are designed to last for a (very) long time without any loss of information and so this is a major advantage over all the other sources listed.

A **Minidisk Player** typically produces an output voltage of 1.0 V rms.

A minidisk player uses a small magnetic spinning disk as its media and the signal is stored digitally. The disks are sensitive to magnetic fields as well as heat and dirt. Error correction means that a small fault or 'drop out' on the disk is covered up and is usually not noticeable. The minidisk player is based around an DAC (Digital to Analogue Converter) and it is the quality of the DAC that determines the quality of the output. Minidisk players can often record in real time using on-board ADC's and provide an indexed layout on the disk for instant random access. The minidisk became increasingly popular as an alternative to cassette tapes but declined in popularity when modern recording devices using flash memory became available. Minidisk players do not suffer from hiss, have the facility for random access, are robust and yet can record. The internal correction system means that the minidisk does not suffer from movement or shock and so it is suitable for use in cars and personal mobile devices.

A **Turntable** typically produces an output voltage of 10 mV rms and the high frequencies are boosted using an RIAA specified pre-amp to achieve equalisation.

The music signal is stored as an analogue signal. The source signal is used to cut contours in a groove in a plastic disk, the two sides of the V shaped groove give a stereo signal. The data stored in the physical surface of the groove is read by a stylus; a hard point which follows the contours of the groove and the movement of which causes an emf to be generated in a very small coils in a magnetic field (moving coil) or very small magnets moving in a coil (moving magnet). The high frequencies are boosted when the disk is made and so must be re-equalised using a special pre-amp. The use of very fine coils makes the stylus susceptible to electromagnetic interference. The main disadvantage of the turntable is that the plastic media is very fragile and decays easily unless stored very carefully. This is a truly retro music source but remains popular and is considered by some audiophile purists as the only valid source of recorded music.

A **Cassette Player** (aka tape recorder) typically produces an output voltage of 0.7 V rms.

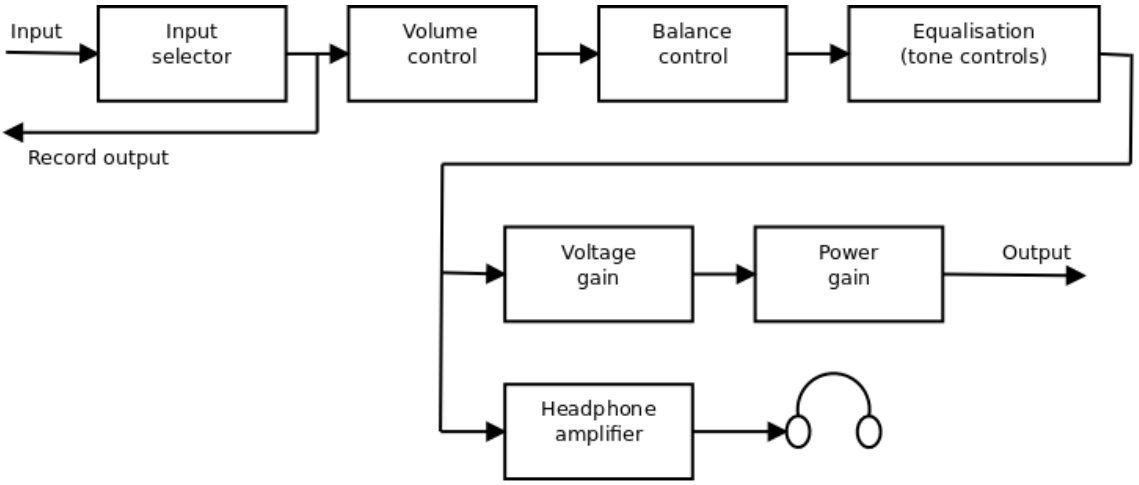
A cassette player reads an analogue signal recorded on a magnetic media in the form of a thin tape. This means the tapes are susceptible to magnetic fields and also physical damage from heat and stretching / breaking. To reduce inherent tape noise, a noise reduction system

is used (Dolby) which boosts the treble frequencies on recording and subsequently reduces them again (and hence also reducing the hiss) on playback. A typical cassette player will be able to record from some other source and also have microphone inputs. A VU meter allows the correct recording level to be selected which in turn depends on the type of tape used. The cassette player is cheap, robust and portable (including use in cars) but suffers from poor sound quality, tape noise, small dynamic range and limited lifetime of the media. Cassettes are now a relic of the past other than in some older GCSE exam past papers.

Amplification in more detail

The amplifier in a domestic HiFi is reproduced twice so that two stereo channels can be dealt with. The various controls such as volume etc will have to act simultaneously on both channels. The two channels are mechanically linked but electrically separate. The domestic amplifier shown incorporates the selector, pre-amps, tone controls and power amplifiers into one integrated unit.

The diagram shows a simple block diagram of a possible domestic HiFi amplifier.



Input selector: this is a switch (often mechanical) to choose between the available inputs.

Volume / balance: these use potentiometers that can attenuate the signal accordingly. Note that logarithmic potentiometers are usually used to provide a smooth change in perceived volume. To allow maximum voltage transfer from the source to the amplifier, the input impedance of the amplifiers should be (much) greater than the output impedance of the source. The input impedance of the amplifier, often determined by the resistance of the volume controls, is set to be about 100 kΩ.

Tone controls: these provide either a boost or a cut for various frequencies. In very high quality systems the tone controls will have a by-pass switch so that they can be made to have no effect on the signal. For domestic HiFi systems a simple bass / mid range / treble arrangement is common but in more professional systems a graphic equaliser is used that allows control of a much narrower range of frequencies.

A **headphone amplifier** may be used in some systems, especially where the pre-amp and main amplifiers are separate. Headphones have an impedance of 600 Ω - 2 kΩ and so require only a small current, therefore the headphone amplifier has a relatively easy task and can be implemented using a simple IC or transistor circuit.

Voltage gain: the signal level needs to be increased, this is usually done in two stages. The voltage of the signal is increased using a simple voltage amplifier circuit. The voltage gain depends on the final power output of the amplifier and the characteristics of the power gain stage.

Power gain: the main job of the amplifier is to increase the power of the signal to a level that can drive the speakers. This means that the voltage (previous stage) and current both need to be increased.

For maximum power transfer the output impedance of the amplifier and the impedance of the speaker should be equal, by convention this is set to be 8 Ω for a standard domestic HiFi system. Consider a power output of 100 W, using $P = V^2 / R$ with R=8 Ω gives V = 28 V. The voltage gain (assuming a CD source with an output of 1 V) will be ×28.

Using $P = I^2 R$ with R = 8 Ω gives I = 3.5 A which is quite a large current to provide and means the power amplifier will need some for of heat sink.

Loudspeakers in more detail

The business end of any HiFi is the bit that makes the noise. The speakers convert the electrical signals from the amplifier into sound waves. The basic principle is that a current flowing in a coil of wire held in a strong magnetic field experiences a force, this force moves a cone that produces the sound waves.

The speakers are required to produce a wide range of frequencies with equal efficiency but as the bass frequencies require much more power than the treble frequencies and the bass units have to physically move much more air than the treble speakers to produce the same perceived sound level this is a very difficult task for a single speaker unit.

In reality the audible spectrum is reproduced using a number of speaker units, each designed for a particular frequency range. The signal is divided into the different frequencies by a crossover so that each speaker unit receives only the frequencies that it is designed for. Typically a bass speaker might handle frequencies below 400 Hz, a mid range speaker would reproduce frequencies between 400 Hz and 4 kHz and a treble speaker would handle everything above 4 kHz although the exact crossover frequencies depend on the type of speakers and enclosures used.

Website

https://www.electronicsteaching.com/Electronics_Resources/DocumentIndex.html

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