Mixers

Juan P Bello
Mixers

- A mixer combines (sums) several individual signals into a single output signal (that can be multi-channel)

- Mixers have many functionalities such as the control of the level and position in the stereo image for each individual signal, their equalization and filtering, grouping, routing to a recording device or effect processor, etc.

- They also serve as a source for phantom power for condenser mics.
Mixer diagram

Input Amplifier -> Filters -> To PFL / Solo -> Fader / Pan control -> Mix bus (L, R) -> Left / Right output fader

Input section -> EQ -> Channel controls -> Master section -> Main output
Input connections

- Input connectors are usually located at the back panel, although in small mixers they can also be located at the top of the front panel.

- Inputs commonly use XLR connectors and a balanced configuration but unbalanced inputs using 1/4 inch jack connectors can also be found for line inputs (less susceptible to noise, interference and long distance).

- Connection conventions: pins point in the direction of the signal.

- Switch(es) to phantom power.
Input section

- Mic/Line switch: switches between inputs
- Input gain/trim: sets the level of amplification of the input amplifier
- For mic inputs high levels of amplification are available (e.g. 0 to 60 dB), for line inputs levels of attenuation/amplification either side of unity gain (0 dB) are available (e.g. -45dB - 15dB)
- Pad button: activates a network of resistors that attenuate high-gain inputs (e.g. from condenser mics or loud environments) to avoid clipping. The level of attenuation is fixed (e.g. 20dB)
- Phase reversal: to compensate for reversed phase from, e.g., a reversed directional mic.
- Basic filtering: low or high-pass filters with fixed parameters (filter out unwanted rumble, hum or hiss)
**EQ (1)**

- The Equalization (EQ) section provides tone control and is usually split into 3/4 sub-sections each operating at a different frequency band

- Sections correspond to high (HF), hi-mid (1k-10kHz), low-mid (200-2kHz) and low (LF) frequency bands

- In simple EQ we only control cut/boost values (in dB). Frequencies are fixed (or simply switchable)

- In parametric EQ we can control frequency variations (within a range), cut/boost, and Q values (Only sections with Q control can be deemed parametric).
EQ (2)

- High and low-frequency band EQ is usually implemented through shelving filters with fixed cut-off frequency.
- Shelving filters slowly boost or attenuate the frequency response towards an area of constant level (a shelf).
EQ (3)

- In mid bands, bell-shaped band-pass filters are commonly used.
- Boost/cut controls the amplitude of the bell, while a "swept-mid" control is used to select a desired center frequency ($F_c$).

- Bandwidth (BW) is the Hertz difference between the points where the filter response decreases 3dB from its maximum at $F_c$.
- $Q = F_c/BW$, thus high $Q$ -> narrow band, low $Q$ -> wide band.
### EQ (4)

- High/low pass filters with steep response at various frequencies
- Enables high/low frequencies to be attenuated without affecting the mid bands (for, e.g., removing unwanted noise)
- Demonstrate the effect of shelving, high/low pass, band pass and variable Q in white noise (see `filtergraph help`)
Channel and mix controls (1)

- Faders are potentiometers consisting of a conductive wiper running along an electrical track
- Carbon tracks are cheap, unreliable and have a grainy feel
- Conductive plastic tracks are expensive, durable and have a smooth feel
- Channel faders control the level of each signal that gets added into the mix bus
- Main output faders control the level of the signals’ sum in the bus
- Faders and rotary level controls follow one of two laws: linear or logarithmic
Channel and mix controls (2)

- The pan(ning) pot(entiometer) controls the position of the signal in the stereo mix image.
- It splits the signal from the fader into two (left/right). The stereo position is determined by the level difference between the two.
- Pan-pot laws ensure “constant” perception of loudness.
- The center drop in level (-3dB) causes a rise in level if summing the channels into a mono signal (avoided with a -6dB drop). However in stereo reproduction -3dB works best, causing no perceived rise (-4.5dB works as a compromise).
- A level difference of 18dB is all is needed to give the impression of full panning towards one channel.
Channel and mix controls (3)

- **Mute/cut**: Cuts the selected track from the mix (or multitrack send)

- **PFL (Pre-fade listen)**: enables monitoring of the mono signal before going to the mix bus (good for adjusting EQ/level)

- **AFL (After fade listen)**: a.k.a SOLO, same as PFL but after the fader
Multi-track mixing (1)

- (Popular) Music recording usually involves two distinct stages:
  - Track laying: where tracks are sequentially recorded to a multi-track device (tape recorder, hard drive)
  - Mix down: previously recorded tracks are played back and combined through the mixer to form a stereo master
- Mixers require signal paths for both stages, known as the channel and monitor paths (respectively).
Multi-track mixing (2)

- Split monitoring: channel and monitor mixers in one frame. Need as many monitor modules as tracks on the multi-track device.
- In-line configuration: All modules double up as channel and monitor modules. Some facilities are doubled (e.g. faders) while others are just switched between (e.g. EQ, aux sends).
Channel grouping

- Simultaneous control of more than one signal at a time
- Commonly one fader controls a set of “slave” faders, thus simplifying the control of signals that “move” together (e.g. drum kit, string section, etc)
- Audio Groups: sum of a number of channels that are controlled by a single (subgroup) fader (e.g. stereo mix outputs)
- Control Groups: group faders are enslaved to a group (master) fader, but the outputs remain separate.
- Commonly, the fader position generates a DC Voltage that controls the gain of a VCA. The audio passes through the VCA instead of the fader.
- Channel faders can be assigned to a group (through a switch), with group faders acting as DC control for VCA gain and channel fader position.
- This opens the door to automation and external control
Routing

- In large professional mixers there are a number of routing switches (e.g. 24, 32, 48) that route the signal path to the multi-track (MT) recording device.

- It is possible to route more than one track.

- Tracks are often grouped in pairs (stereo channels of a given track) with pan pots used to distribute the signal between them.

- Large numbers of routing switches consume space, thus rotary knobs, odd/even/both switches, and shift functions are used.

- Bus trims are used to control the overall level of the send to MT.

- Routing is usually done using summing buses (effectively audio groups). Channels can be directly routed to a track that will be used exclusively (thus avoiding bus noise).
Other functions

- Aux(iliary) sends are additional mix buses that appears as outputs from the console and are used for FX, foldback to musicians, etc.
- Each module can send to auxiliaries (with a certain gain). Aux master controls gain, basic EQ and (if a stereo bus) panning.
- Sends can be taken before or after the fader, from the channel or monitor path and can be muted.

- Effect returns are extra inputs for external devices (e.g. reverb units). They have all basic controls and often feed the mix.

- Some mixers provide dynamics control per module to avoid the use of external devices
- The dynamics section can incorporate high-quality compressors and expanders, with the ability to side chain EQ (providing frequency-driven control) and link actions for stereo pairs.
Mastering section

- The master section commonly resides in the middle or right-hand side of the console (true of split and in-line configurations). Some of its controls include:
  - Master faders (stereo/mono): separately controlling the overall mix level and the monitor level
  - Group master faders
  - Monitor selection: switching the signal that goes to monitors between MT device, aux sends, main mix, CD players, etc
  - Global configuration for mic/line input switching, channel/monitor paths, aux sends master control, etc.
  - Slate: feed from console microphone to stereo output (and a number of other destinations for talkback)
  - Control of signal routing to foldback
  - Facilities to check compatibility with mono, monitor phase reversal, quick attenuation of loudspeaker level (DIM), etc.
Technical Specifications (1)

- Microphone inputs are typically of a few millivolts, so amplification is needed to bring it up to line level
- The amplification stage results in an increase on the level of microphone and amplifier’s noise (which must be as low as possible)

- The reference level is 0dBu (775mV). A 200 Ω source resistance on its own generates -129.6dBu (0.26µV) for a BW of 20kHz.
- The amplifier’s equivalent input noise (EIN) is commonly added to this
- EIN = -128dBu (or -126.6dBu) are very good, as long as the reporting conditions are the ones specified above.

- Output noise with all faders at minimum should be no more than -90dBu
- All unused channels should be switched off and faders brought to a minimum
- It is important to ensure that aux outputs also have a good noise level
Technical Specifications (2)

- High input impedance and low input impedance:
  - Microphone input impedance should be at least 1kΩ
  - Line input impedance should be at least 10kΩ
  - All outputs should have low impedance (200Ω)

- Frequency response should be flat between 20Hz-20kHz (and within 0.2dB) for all input/output combinations
- Outside that range it should fall such that unwanted frequencies are not amplified (e.g. radio and sub-sonic frequencies)

- Distortion should be quoted at maximum gain through the mixer and at a high output level (e.g. +10dBu or more)
- It should be less than 0.1% of total harmonic distortion (and even smaller, 0.01%, for low-gain line level inputs)
Technical Specifications (3)

- Above the maximum electrical output level of the mixer (e.g. 20-24dBu) clipping will occur.
- Although it is difficult to clip the output stages of a mixer, clipping may occur due to excessive EQ boosting (without proper fader compensation), or the presence of high-level signals.

![Maximum Output Voltage Diagram]

- In analog mixers, a signal from one input may induce a small signal in another channel (Crosstalk). This should be well below the level of the correct output signal (-80db or more).
- Crosstalk is worse at high (-60dB @ 15kHz) and very low (-50dB @ 20Hz) frequencies.
Useful References

  – Chapter 5: Mixers