Edinburgh University Students' Association

General Tech Training

Martin, Cat, Louis, Rich and the rest

Spring 2017

Abstract

This is the handout for the **General Tech Training**. It contains several important concepts that will help you to form/extend a solid technical knowledge basis.

1 Introduction

In the **Edinburgh University Students' Association** we take pride in the fact that our emplyees are capable of dealing effectively with technical problems, stressful situations and deadlines, while maintaining a positive "can-do" attitude. The Low Tech Training is thus aimed at helping you to form a strong basis of technical knowledge. It examines several important concepts and goes over important skills that are required for you to be a successful technician in this company. You will gain basic knowledge of electricity, sound systems, lighting systems and AV

systems. We shall also look over fault finding and troubleshooting for each of the aforementioned systems.

2 Power

Let us start from the beginning. Every piece of technical equipment needs electricity to function. Today we take electricity for granted, but often we are unaware of exactly how it works. Here we shall take a look at a simplified description of this physical phenomenon.

2.1 Electricity

One often hears the words "current", "voltage" and "resistance". It is very important to understand these three concepts well. Here we will look at a very brief explanation of them. If you want to learn things in more detail, take a look at the following resources: howequipmentworks.com and wikipedia.org.

It is important that you know about electricity. It will help you to better understand electrical safety. Here we describe some of the basic principles of electricity:

- Current is related to the flow of electrons and is measured in Amperes.
- Potential difference is what makes the electrons flow (current) and is measured in "Volts". There are many sources of potential difference such as batteries, electrical supply sockets at home and hospital etc. Current is directly related to the potential difference, and this forms part of Ohms Law.
- Resistance is something that resists current flow and is measured in Ohms. Current is inversely proportional to resistance. This relationship forms part of Ohms Law.
- Ohms Law ($V = IR$) defines the relationship between *voltage (V)*, *current (I)*, and *resistance (R)*. If you know two of the three components of Ohms Law, you can find out the third.
- Current can be DC (Direct) or AC (Alternating). In DC, the electrons flow in one direction whereas in AC, the electrons alternate their direction.
- Transformers are needed to make high voltages needed to economically send current over long distances. Transformers work only with AC, and that is why the power company supplies your home and hospital with AC.

2.2 Electrical Cables

There are numerous different types of electrical cables. What is common for all of them is that they are used to provide **electrical power**. **Electrical power** is the rate, per unit time, at which electrical energy is transferred by an electric circuit (which includes cables). Now that we know what *voltage (V)* and *current (I)* are we can express *power (P)* with the formula: $P = IV$. The SI unit of power is the **watt**.

The plugs of electrical cables usually are defined by what current they can carry - 13 Amperes, 15 Amperes, 16 Amperes, etc. Thus, referring to the power formula,

a cable plug with higher Amper classification can transfer more electrical power. This is important as for more powerful electrical equipment, you need to provide a suitable cable, otherwise **it will melt**.

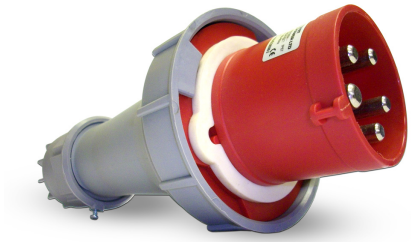
Since we are in the UK we shall only look at the UK standard cable plugs. In the **Students' Association** you will most commonly encounter the following electrical cable plugs:

- **13 Amp:** This is your standard plug/cable that you use to power laptops, desk lamps, iPhone chargers. In the Students' Association we use it to provide power on stage, charge laptops during conferences as well as to get power to our sound and lighting desks, projectors, etc.

- **15 Amp:** This cable is almost exclusively used to power lights on a lighting rig. More detail is provided in the **Lighting Training**.

- **16 Amp:** This cable is widely used for different applications that require more power that what a 13 Amp cable can provide. The 16 Amp plug, unlike the 13 Amp one, can be used to provide power in an outside environment as it is waterproof.

- **32 Amp:** This is a huge power plug that is used to provide even more power. They are often plugged into **Power Distribution Boxes**, which have multiple 16 Amp (or lower) sockets.



- **63 Amp:** Similar to 32 Amp, but huger and can provide even more power. Additionally, a 63 Amp cable can carry three-phase electrical power.

3 Introdution to Sound and Audio Systems

In physics, **sound** is a vibration that propagates as a typically audible mechanical wave of pressure and displacement, through a transmission medium such as air or water. Humans can hear sound waves with frequencies **between about 20 Hz and 20 kHz**. Sound above 20 kHz is called **ultrasound** and below 20 Hz is called **infrasound**.

Sound by itself can be very loud. If you do not believe that, visit a kindergarden at launch break. However, it is often not loud enough. To help mititgate this problem we use a **Sound Reinforcement System**.

3.1 Structure of a Sound Reinforcement System

A **Sound Reinforcement System** is the combination of microphones, signal processors, amplifiers, and loudspeakers in speaker cabinets that makes live or prerecorded sounds louder and may also distribute those sounds to a larger or more distant audience. Such systems can range from very basic setups with a single microphone and/or music source up to massive line array systems with digital mixing desks and dozens of inputs. In general, though, the same principles apply to all of these systems, which helps to simplify them. A diagram of a typical sound reinforcement system is presented on Figure 1.

The **INPUTS** section contains the different sources – basically anything that can make noise. We have to deal with a variety of sources, e.g. CD players, laptops, iPods, Microphones, DI boxes, etc. These all behave in slightly different ways which you will come across over time.

Then there is the **MIXER** section - it is possible to pass sound without a mixer, but then we have little or no control over it. Because we want to be able to combine signals together, the mixer is essential to creating an evenly balanced sound. They can also provide us with ways to route the signal to different sets of outputs (for example when mixing monitors for bands). Mixers, also called Mixing Desks, will be covered in more detail further on.

The first element in the **OUTPUT** section is the **power amplifier**. It increases the amplitude of the audio signal coming out of the mixer. Power amplifiers come in different shapes, sizes and power ratings. Last in the chain, after the amplifier, we have the **speakres** which turn the electrical signals from the amplifier into sound waves. Speakers come in many flavours – some cover specific frequencies (e.g. subwoofers, or subs, which are designed to provide low frequency noise), some are designed to cover wide angles, while others are very directional. Speaker design is a bit of a dark art and there are some fascinating things that can be done!

It is worth noting that sometimes these elements can be combined together – sometimes you get mixers with built-in amplifiers (these are called powered mixers, we do not have any of these, but you may come across them), or more commonly, speakers sometimes have the amplifiers built in (these are called active speakers. If the amplifier is separate, it is a passive speaker.) The small Mona-

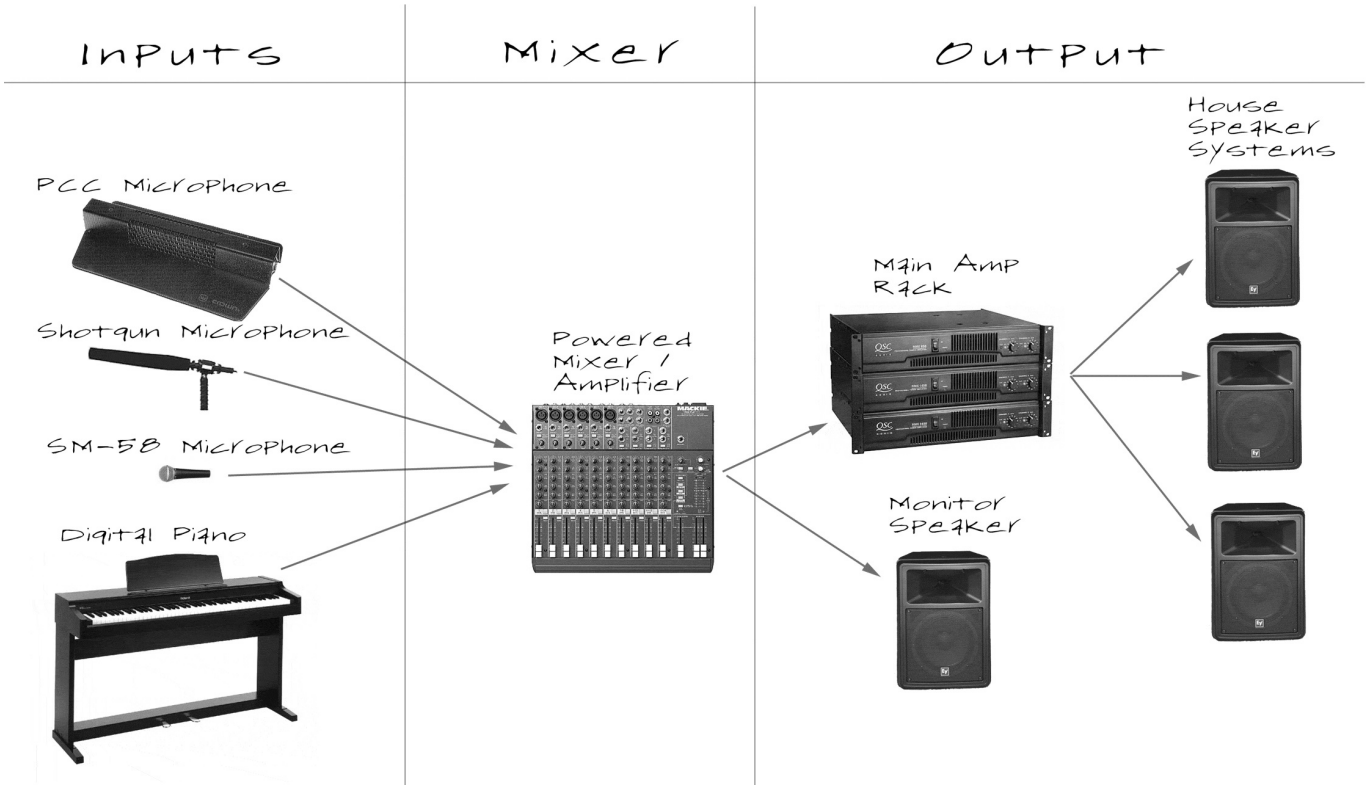


Figure 1: Basic structure of a sound system.

cor PAs that we give to societies have a mixer, amplifier and speaker all built into one box. They are very neat, but generally less useful for our purposes!

3.2 Signal Types

The electrical signals that travel through sound equipment come in a variety of sizes. There are four main signal levels that you will need to know and understand. These are:

- **Microphone Level** - This is the level at which signal is sent out of a microphone. Because this is only voltage created by the movement of a coil within a microphone, it is very weak and therefore needs to be amplified using a pre-amp.
- **Line Level** - This is the level at which professional audio equipment (CD players, mixing desks, DJ mixers, etc) outputs signal. It is much more powerful than microphone level and can be fed straight into an amplifier.
- **Phono Level** - This is the level at which signal is generated by vinyl record decks as the needle bounces along the grooves of the record – it is a bit louder than microphone level, but still a long way from line level. Such signals have a slightly stronger bass due to the mechanics of how they are generated. To compensate for this, they require special phono preamps which are built into most DJ mixers and some domestic hifi systems. It is not possible to con-

nect them to other inputs, and if you connect a line level source to a phono preamp, it will sound distorted.

- **Speaker Level** - This is the level at which amplifiers send out signal to speakers. It has to be powerful enough to make the speaker cone move and so is much more powerful than either microphone, line or phono levels.

3.3 Balanced and Unbalanced Signals

As sound signals tend to be very small electrically-speaking, they are susceptible to interference from external sources (e.g. radio waves, electromagnetic sources like power cabling, lighting transformers etc). This usually manifests as a buzz, or as other noises, especially over a long cable. Balancing offers an efficient solution to this. Knowing the exact theory is not necessary, but it is very interesting.

If you take a signal cable, and you introduce a source of interference, you end up with the same interference acting roughly equally on all the cores of the cable. This interference is then amplified by the preamps and amps in a system until it's audible, as shown on Figure 2.

Balancing involves sending an inverted signal along an adjacent cable core. This means that the same interference affects both signals, as shown on Figure 3.

At the other end of the cable, the blue signal core gets inverted again, which flips both the signal and the interference, as shown on Figure 4.

If both the red and blue signals are added together, an even stronger version of the original signal is produced and the interference is canceled out, as shown on Figure 5. This is a balanced signal.

Thus a balanced signal is far less susceptible to noise and interference than an unbalanced signal.

3.4 Balanced and Unbalanced Cables

As there are balanced and unbalanced signals, there are also balanced and unbalanced cables, i.e. cables that carry balanced and unbalanced signals, respectively.

A cable carrying **unbalanced signal** needs two connectors - one of these is "ground" and the other carries the signal.

A cable carrying **balanced signal** needs three connectors - ground, signal and an inverse copy of the signal. All the connecturs are wrapped around each other so that the external noise can affect them equally.

3.4.1 Balanced Cables

There are two types of balanced cables that you will encounter in the Edinburgh University Students' Association:

- **XLR:** This is the most common type of cable in the sound world. Frequently referred to by musicians as "mic cable". Has three pins/holes.

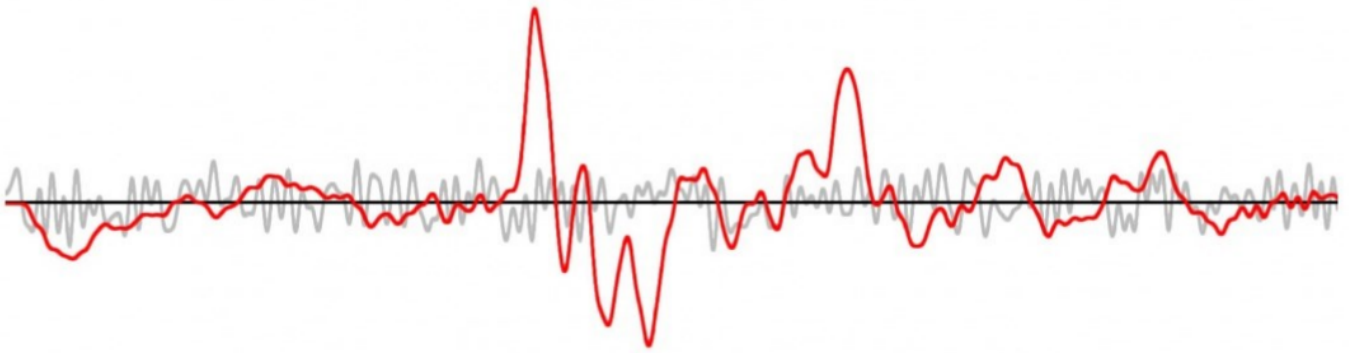


Figure 2: An image of a signal (shown in red) with some interference (shown in grey).

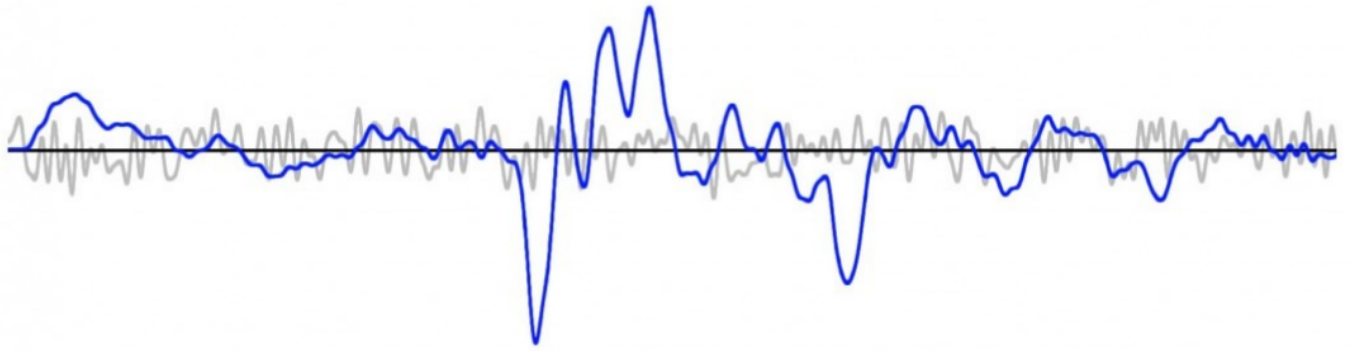


Figure 3: An image of the inverted signal (shown in blue) with the same interference (shown in grey).

- **Balanced Jack (TRS):** This has three connections: tip, ring and sleeve. It is explained in more detail in the **Sound Training**. Not to be confused with unbalanced jack (guitar cable).

3.4.2 Unbalanced Cables

There are three types of unbalanced cables that you will encounter in the Edinburgh University Students' Association:

- **Unbalanced Jack (TS):** This has two connections: tip and sleeve. This is a guitar cable, do not confuse it with balanced jacks! Commonly known as 6.35mm or 1/4inch jack.

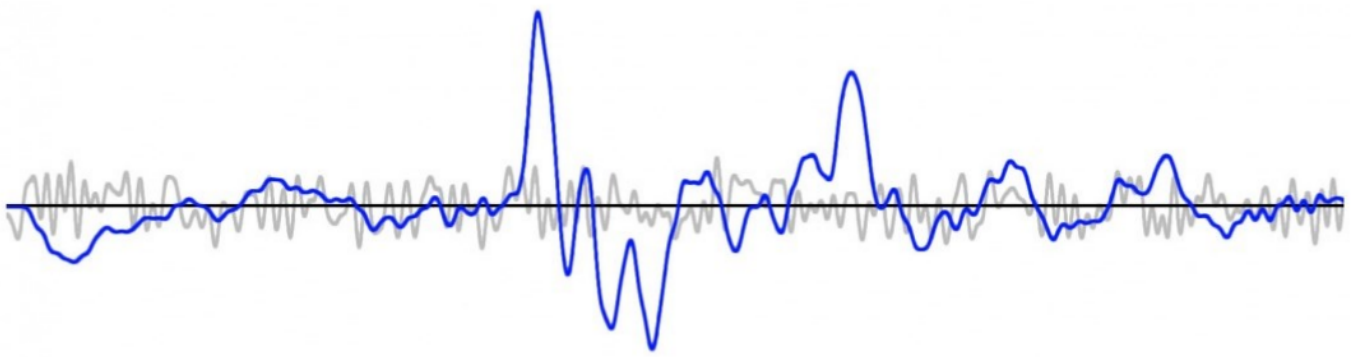


Figure 4: An image of the re-inverted signal (shown in blue) with the now inverted interference (shown in grey).

Figure 5: An image of the produced stronger clean signal (shown in red) with no interference.

-  **RCA:** This is commonly used by DJ equipment, CD players, hi-fi types. Frequently referred to as "phono cable".

-  **Minijack:** This is used by laptops, iPods and other consumer equipment. Commonly referred to as an "aux cable", "3.5mm jack" or "Hi, can I play my laptop through your speakers?". Enjoys popping out mid-gig. Note that, while there are three connectors, it is unbalanced. This is because it carries stereo (two channel) signal.

3.4.3 Speaker Cables

The previously presented cables carry microphone, line and phono level signals. However, cables are also needed to carry

speaker level signals:

- **Speakon (NL2, NL4, NL8):** This is used to carry speaker level signal. Comes in several forms, with the number indicating the number of cores. The cores come in pairs, so NL2 can carry one signal, NL4 can carry two and NL8 can carry four signals.

3.5 Microphones and DI Boxes

Often, audio signal is inserted into an audio system through a **microphone** or a **Direct Injection (DI) box**. This section provides an introduction to both of them.

3.5.1 Microphones

The Edinburgh University Students' Association owns a number of microphones. Microphones can be described in terms of their frequency response, sensitivity and polar pattern (directionality). All of this will be covered in detail during the **Sound Training**.

There are essentially two different kinds of microphones – **condenser microphones** require a power supply to operate, while **dynamic microphones** do not. This power supply is normally fed along the microphone (XLR) cable from the mixing desk. It is called phantom power, and is usually supplied at 48 Volts. On some desks, it is switchable by channel (or group of channels), while on others it is a global setting that can be found somewhere on the master section of the desk.

Dynamic microphones tend to be much more rugged. A typical dynamic microphone is the **Shure SM58** (See Figure 6), which is used for vocals. It is almost indestructible and can be found on most band riders.

Figure 6: An image of the Shure SM58 microphone.

Condenser microphones are more sensitive, allowing them to pick up subtle frequencies. The **AKG C391** (See Figure 7) is an example of a condenser microphone. It is great for wind instruments, strings, drum overheads, etc.

3.5.2 DI boxes

A DI box is used to connect a line level signal to a microphone pre-amp on a mixing desk. This is useful when plugging, for example, a keyboard or acoustic guitar with a line level output into the multicore at stage. As well as this primary function, DI boxes also have the benefit of balancing an unbalanced signal (also useful over long runs where an unbalanced

Figure 7: An image of the AKG C391 microphone.

cable would act as a giant antenna). They usually have a ground lift switch on them, which can be used for eliminating 50Hz hum from ground loops, and sometimes have pad buttons that attenuate the output by a chunk. Some DI boxes are active and require phantom power, while others are passive and do not. An example of an active DI box is the **BSS AR133 Active DI Box**, which can be seen on Figure 8.

Figure 8: An image of the BSS AR133 Active DI Box.

3.6 Mixing Desks

In audio, a **mixing console (mixing desk)** is an electronic device for combining (also called "mixing"), routing, and changing the volume level, timbre (tone color) and/or dynamics of many different audio signals, as produced by the devices presented in the **INPUTS** section of Figure 1. Figure 9 provides a simple image of the workings of a mixing desk. Mixing desks can be either analogue or digital, depending on whether they work on analogue or digital audio signals.

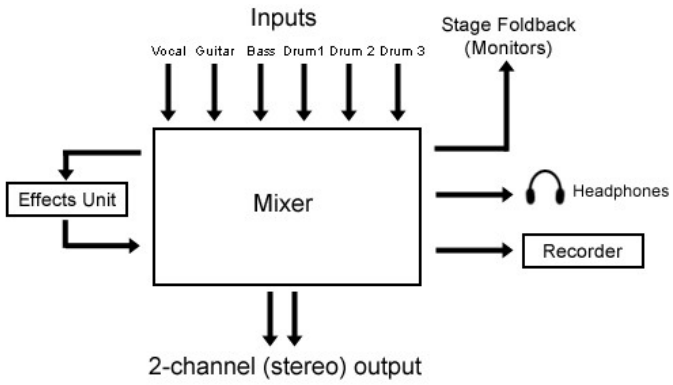


Figure 9: A simple diagram of a standard mixing desk.

At the **Edinburgh University Students' Association** we have several mixing desks of different shapes and sizes. They are covered in more detail in the **Sound Training**. Here we use the **Midas Verona**, a.k.a. Matilda, as an example, as it is our most complex analogue desk. All analogue desks are based around the same concepts , although many remove or simplify a lot of the features. We shall now look at the two types of sections an analogue mixing desk has - **Channel Strip** and **Master Section**.

3.6.1 Channel Strip

A channel on a mixing desk is responsible for a single input, which could be a microphone, DI box, etc. Consequently, on analogue desks, the number of channels limits the number of inputs you can have. The cahnnel strip gives you control to change the amplitude of the input signal, change its sonic attributes and deside how it will be mixed along with the other channels. A detailed description of the channel strip is provided on Figure 10.

3.6.2 Master Section

The master section is where all the master volume controls for each output can be found. On the Midas Verona, it is separated into two parts - **Auxiliary (AUX) Master Section**, shown on Figure 11, and **Main Master Section**, shown on Figure 12.

3.7 DJ Setups

A DJ set-up consists of two parts – a number of sources (whether they are CD players, turntables or laptops) and a DJ mixer.

Normally, a DJ set-up will also include booth monitors – these are so that the DJ can hear the music from a source close to them, and (talent permitting!) stay in time.

The Edinburgh University Students' Association owns a number of different DJ set-ups – the one used in the examples is our second most advanced system, the DJM800 and two CDJ1000s. This is commonly used for club nights, and can also be used in other venues from time to time. There are two ways to connect it up:

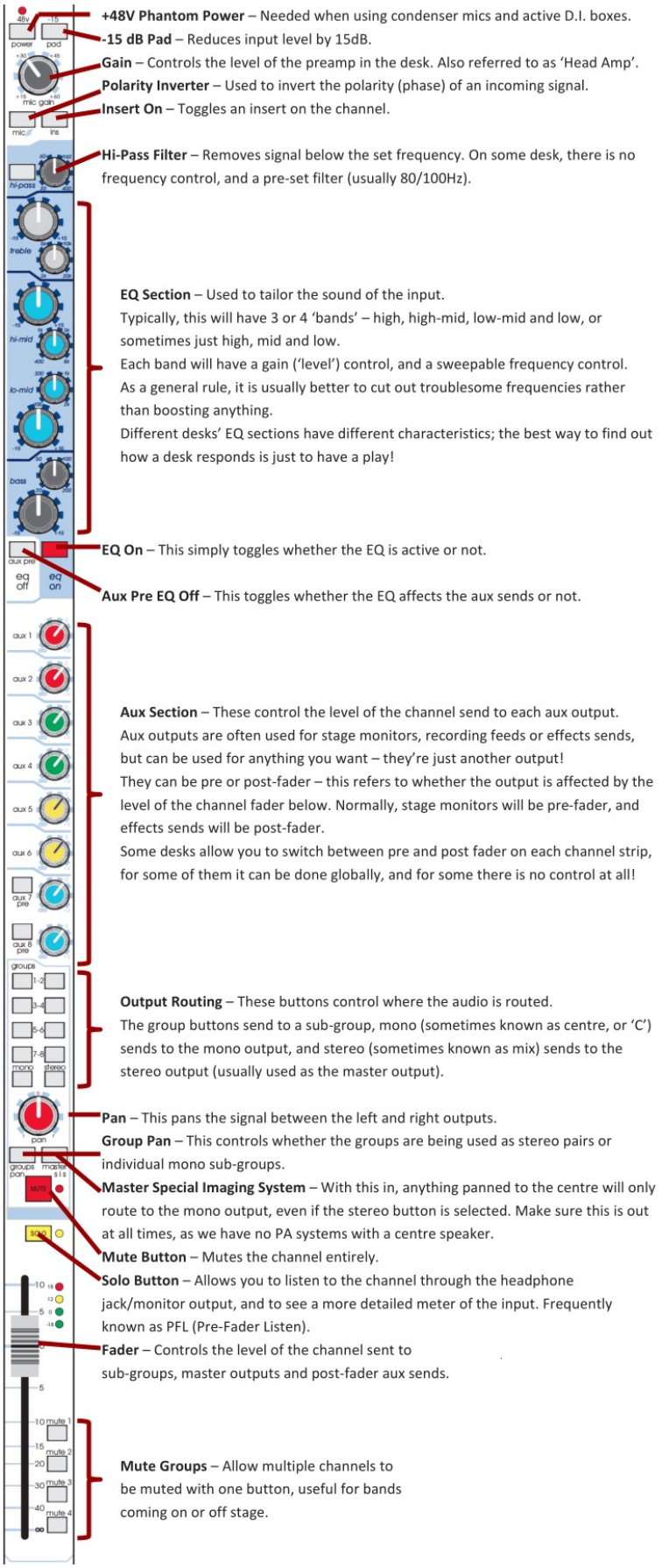


Figure 10: An image of a standard mixing desk input strip.

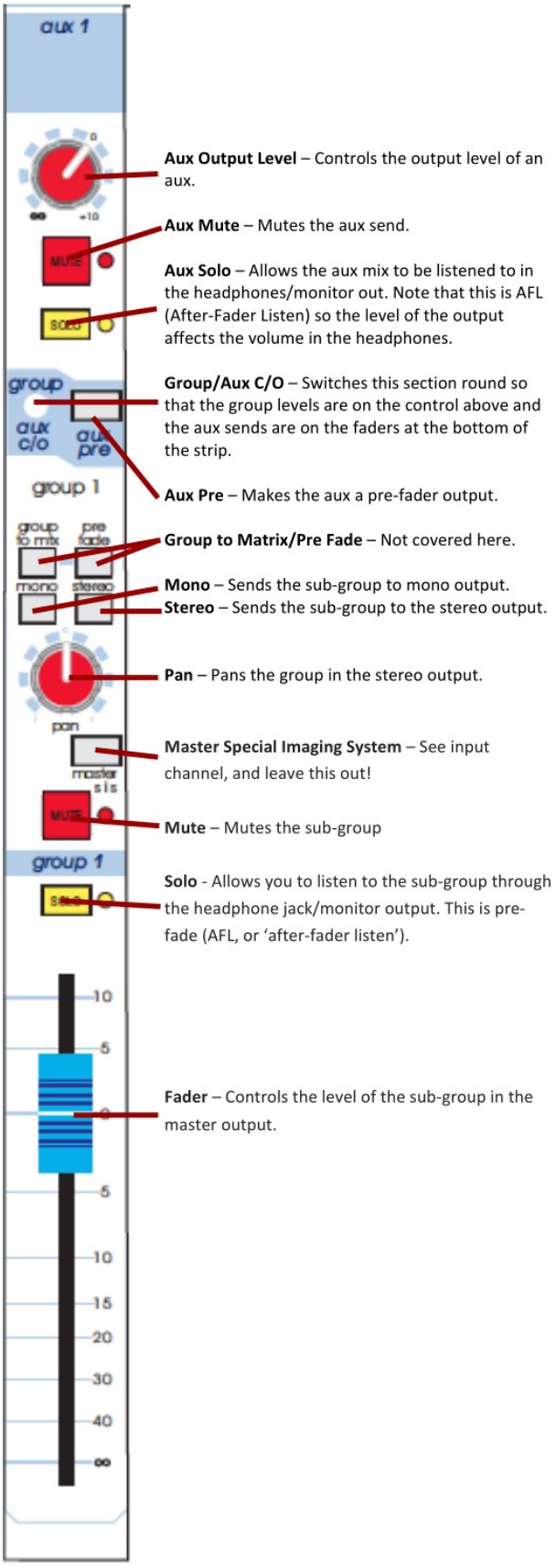


Figure 11: An image of the Auxiliary (AUX) Master Section.

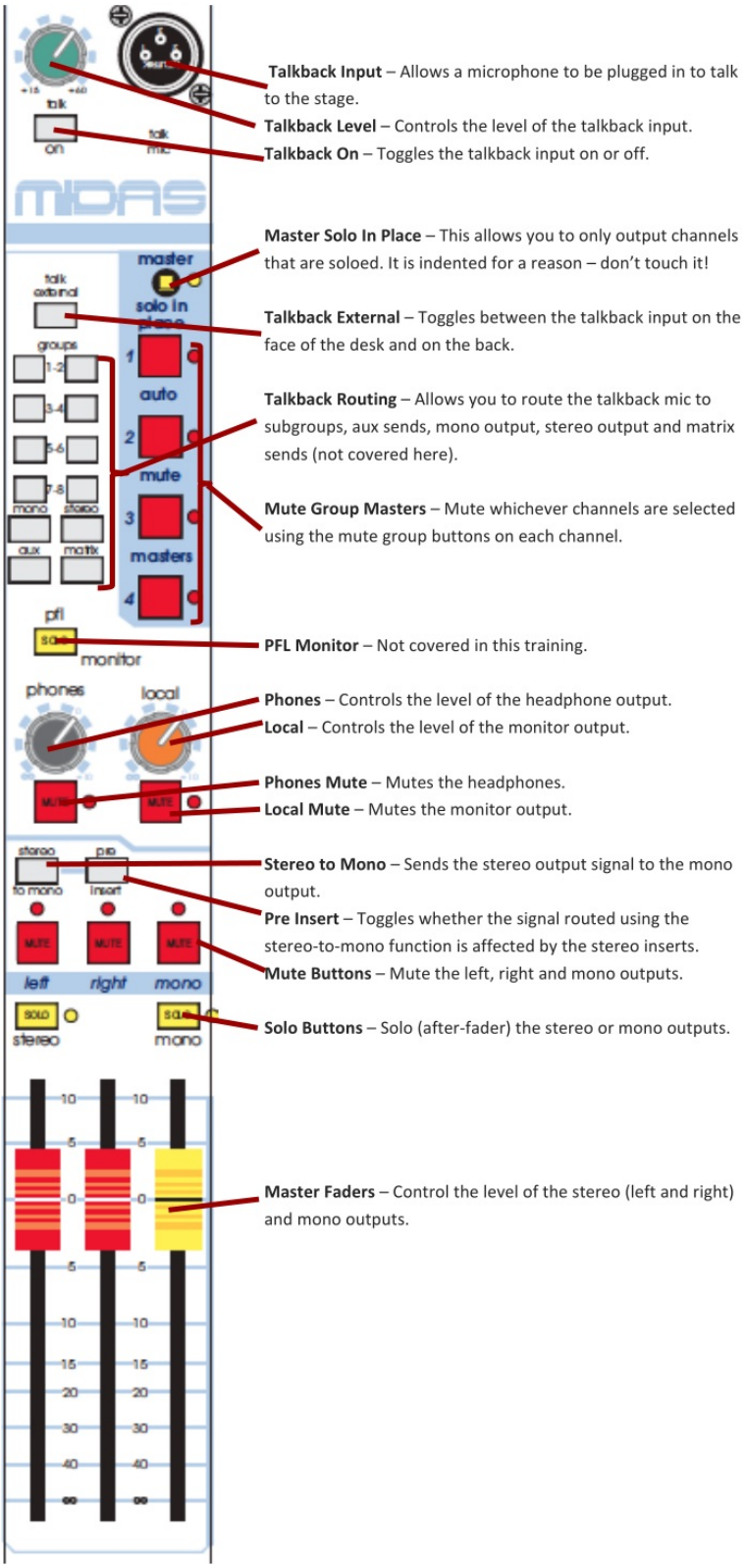


Figure 12: An image of the Main Master Section.

- Using digital connections between the CDJs and mixer, as shown on Figure 13.
- Using analogue connections between the CDJs and mixer, as shown on Figure 14.

These two examples are completely interchangeable – no matter how much a DJ may try to talk you one way or another, there is no difference in sound output. Also note that the links shown above are all standard RCA cables, you do not need different ones to transmit analogue and digital signal. The DJM800 and DJM900 are our only mixers that supports using digital inputs, but the CDJ2000s, CDJ1000s and CDJ800s can all transmit digital signal.

When using turntables, the set-up is slightly different – we need to connect the turntables into the phono inputs of the mixer. This is because the turntable output is very low, and needs a pre-amplifier (in the phono inputs of the mixer) to amplify it to line level.

EUSA also owns several all-in-one setups, the **Numark iCDMix**. These contain two microphone inputs, 3 line/phono inputs, 2 CD players and an iPod dock, and are suitable for a wide variety of events – whether they are pub quizzes, small club nights, society socials, small presentations or just providing some background music!

DJs are a funny bunch, and like to play their music as loud as physically possible. Our DJs have been trained to use a reasonable gain structure, but external DJs may try to push their output as high as possible. If you ever see red lights on the meters of a mixer – either the individual channels or the master outputs – turn it down and explain nicely to them that this can damage the speakers. If they continue, explain less nicely!

3.8 Basic Fault Finding

Often an audio system would not behave the way it is supposed to be or would not turn on at all. That could be due to various reasons, such as incorrect patching of cables or faulty equipment. This section presents a simple technique that will prove useful for finding faults quickly and efficiently.

The first thing to consider is how far the audio signal is getting – many types of equipment have a level meter or a signal LED that shows when a signal is present. Using these can be a very quick way to locate an issue, or at least narrow the problem down. Once the potential root of the problem is narrowed down a bit, try to solve the issue using what you have to hand – if a microphone does not work when plugged into channel one of a mixer, try it in a different channel to see if that makes a difference!

If you are still struggling, you can use a simple logical approach. Most PA systems run in stereo, so swapping the left and right signals over at strategic points can help to narrow down where the problem lies. For example, if one side of the PA does not work, try swapping the Left and Right outputs from the desk. If the problem stays on the same side, the fault lies after the desk (with the cabling, amps or speakers themselves). If the fault changes side, then the issue lies before the output from the desk. You can repeat this at key

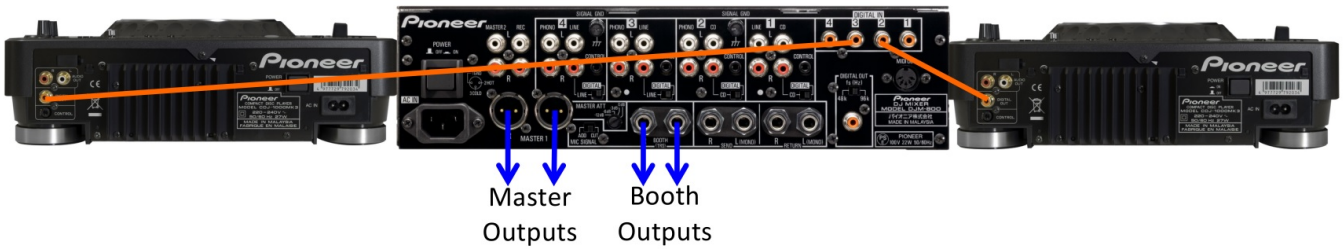


Figure 13: An image of the back panel of the DJM800 with two CDJ1000s, with digital connections.

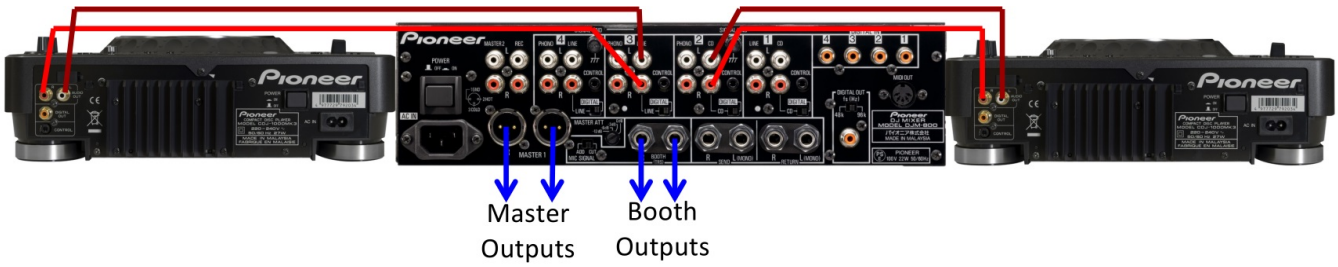


Figure 14: An image of the back panel of the DJM800 with two CDJ1000s, with analogue connections.

points throughout the signal path to help narrow down the specific cause.

Another thing worth considering is that items of equipment that get higher levels of mechanical stress are much more likely to fail – so a cable is more likely to break than a microphone. You will generally find that replacing the cable will fix most faults – make sure you tape up the ends of the broken cable and leave it in the office though, otherwise someone else will have to go through the same fault-finding exercise soon.

Figure 15 presents a few common faults, along with the most likely cause and a solution.

4 Lighting

Some sort of basic lighting training (if applicable). To be filled by the lampeys.

5 AV

To be filled as well.

6 Conclusion

To be filled with some random stuff.

Fault	Likely Cause	Solution
No signal from microphone	Broken cable	Replace cable
	No Phantom Power if condenser / active DI	Turn on Phantom Power
Distorted signal from line level source	Source is connected to a mic or phono preamp	Connect to line input or use DI box
Buzz from DI box	Ground loop	Switch Ground Lift to other direction to see if it helps
Buzz through PA	Unbalanced cable	Replace unbalanced cable with balanced cable
	Dirty power supply	Try connecting to a different power socket.

Figure 15: A few common faults, along with their likely cause and a solution.