

About Balanced headphone Amplifiers

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Different kinds of balanced applications and their advantages

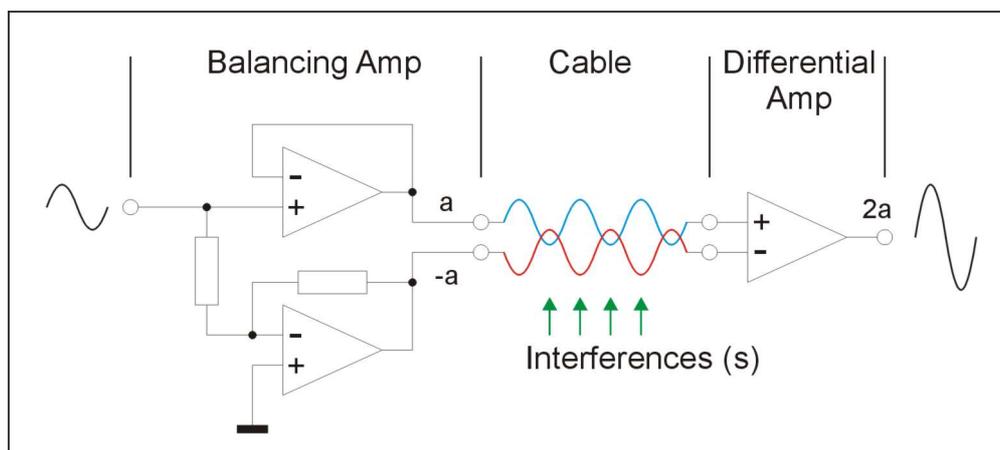
The balanced signal line ...

... is used to maximize the noise and hum immunity of the signal line.

Who ever made a military service perhaps knows about the "field telephone" which is a very simple thing without any electronics inside and without a power supply. It is hooked to another field telephone with a simple twisted cable. This cable can be as long as some kilometers and communication is still possible. This is caused by the advantages of the twisted cable, the balanced line.

An easy and reliable approach to a balanced line is the use of transformers on both ends. This can be done even without the need of power. Unfortunately those are expensive and suffer from nonlinearities.

Electronically balanced signals can be made with two op-amps. Here, out of a present unbalanced signal (a) an inverted or 180° phase shifted signal (-a) is formed with another op-amp.



Both signals are fed to a cable consisting of a twisted pair which must not necessarily be shielded.

On the way to the receiving device interferences may show up and disturb the signal.

Inside the receiving device the signals are input to a differential amp. As the name explains, this amp forms a difference out of both signals like this: $a - (-a) = 2a$. The same procedure is applied to the interferences: $s - s = 0$.

As an ideal result there is double the original signal amplitude and no interferences on the output of the differential amp. In the real world this is not achieved by 100%. You have to consider voltage- and impedance-ratios what can be determined as CMRR or Common Mode Rejection Ratio. The higher the technical efforts, the better the results.

Besides the fact that balanced signals offer enhanced interference immunity compared to unbalanced signals, the next advantage is that the screen from the cable only serves for the protection of the signal and for the potential equalization between devices. It only has a static function.

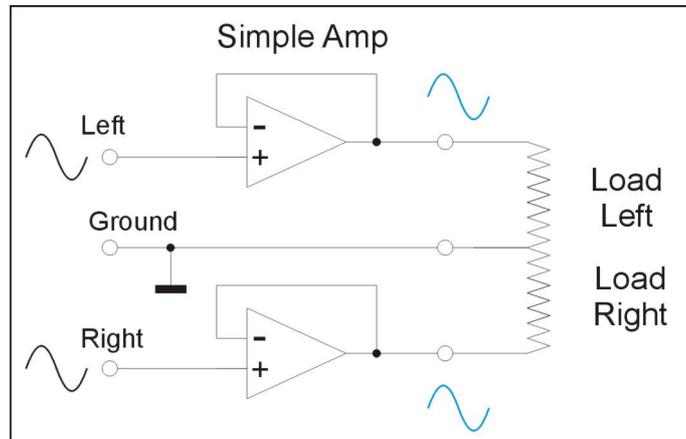
Looking at unbalanced cables, here the cable shield also serves to leading back signals.

The ground of unbalanced connected devices is not static but is modulated by the reflux of the signals.

Whereas a balanced line serves mainly to have an interference-free signal distribution and a static ground, there are other things in the forefront concerning ...

“Balanced” amps.

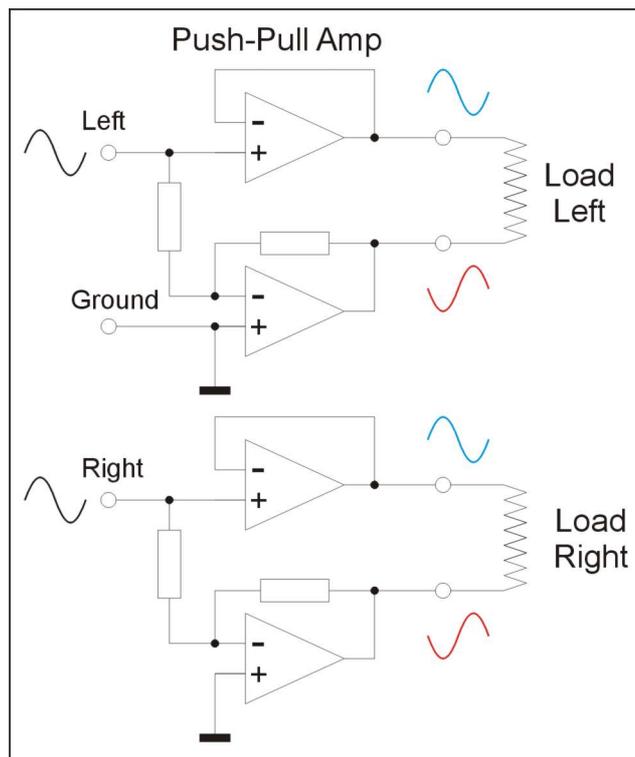
Let’s take a look at a simple amp:



The left and right input signals are amplified and are fed to the left and right load.

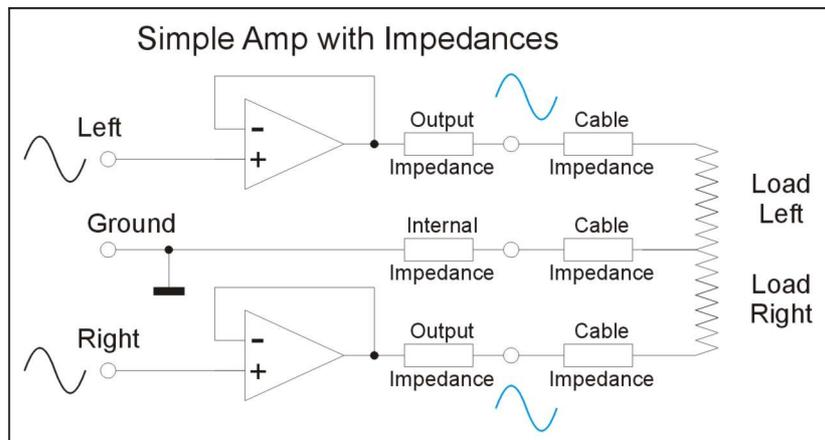
“Balanced” amps are not new at all but known for a long time e. g. in car radios where this technique is taken to achieve quad power out of a limited supply voltage (12 V). “Balanced” amps are also called Push-Pull Amps or BTL amps (Bridge-Terminated-Load).

Take a look:



The input signals are fed to the loads via two amplifiers per load. The trick is, that one of these amplifiers is working “normal”, the other inverted respectively 180° phase shifted. While one amp is “pushing”, the other amp is “pulling”. In doing so the output amplitude is doubled and the power is fourfold compared to a “normal” amp with the same supply voltage.

Unfortunately the real life is not as easy as the above simple schematics.
Here is the “normal” amp with problem zones:



Besides the load, which has to be driven there are several other impedances which should be taken into account. All these are able to impair the proper driving of the load.

Impedances are a complex mix of resistive, capacitive and inductive parameters which may lead to an instable operation of an amp when the capacity of a cable is too high.

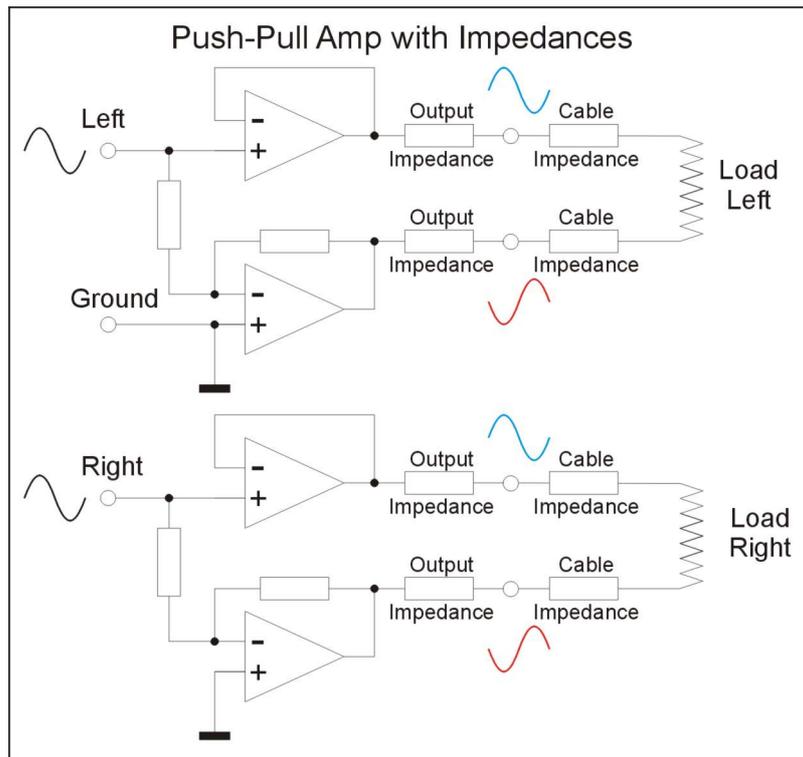
To keep things simple, for the following examinations only the resistive parts shall be taken into account.

Every above resistive load will cause a voltage drop which is responsible for a none-linear behavior inside the system.

Some problems are apparent at first glance:

- The higher the resistive load, the lower the parasitic impedance influences
- The lower the resistive load, the higher the parasitic impedance influences
- The lower the output impedance of an amp, the lower its influence on the transmission quality
- Using “normal” headphones with phone jacks will lead to relatively big faults caused by the common ground cable and the less than perfect connectivity from phone jack to phone socket because of much too big contact surfaces.
- The ground potential is not static but suffers from voltage drops caused by the internal impedances and the influence of the common ground cable from the “normal” headphone. The ground potential is polluted by a summed left + right signal, a mono signal (!!), which can be measured and heard as crosstalk and intermodulation.

A balanced amp will show up like this:



Instead of six problem zones we fortunately got not twice the issue but only eight.

The signal quality rises because there is no common ground as well as there is no load applied to the ground potential.

But it is not everything gold with a push-pull amplifier.

Beneath higher costs of a specific product because of doubling the components there are the following points taken into account:

- Double output impedance because two impedances per channel
- Higher static noise because of double gain
- Risk of more distortion because of two amps per channel

Using a push-pull amp as a headphone amplifier is most times not because doubling the output amplitude. Especial when there are only low impedance headphones to drive.

There is more than one amp in the Lake People / Vioelectric program range with more than enough amplitude – even for high impedance loads.

So, what is the sense of a balanced headphone amplifier ?

As mentioned earlier a “simple” amp has the ground potential as its reference point.

To be more precise, it is not any point of the ground plane but the ground pin(s) from the transformer. The output amplitude swings preferably symmetrical around this reference point otherwise we would talk about DC offset.

The theoretical maximum effective output voltage swing is calculated simplified as follows:

$$\frac{\text{Amount of the operating voltages}}{2 \times (\text{root } 2)} \quad \text{resp.} \quad \frac{\text{Amount of the operating voltages}}{2,83}$$

Inside a “**normal**” **amp** a voltage is sent to the load (the voice coil of the headphone). This voltage is coming back via a common cable for both channels to the ground contact of the headphone socket and from there to the foot-pin of the transformer, the true reference point. Because the wires from the headphone to the amp as well as the contact(s) and the ground planes inside the amp don’t have a resistance equaling zero but have measurable resistances, they represent a load where a voltage is dropped. So the ground plane is not static but will be modulated with the scraps from the left + right channel which is a summed mono signal. This can be heard and measured as crosstalk and intermodulation. The amount is influenced by the circuitry itself (output impedances), the layout of the amp, the quality of the headphone cable, the ratio between the sum of the parasitic impedances to the impedance of the voice coils ... and more.

The better amp is the **balanced amp** or push-pull amp which consists basically of two amps per channel, one carrying the normal signal, one the inverted signal. The load, the voice coil, is now pushed and pulled between the operating voltages and has nothing to do with the ground potential. So the ground plane is not polluted by any parasitic influences and the crosstalk is not harmed. Also the cables of the headphone are clearly assigned: Two cables to each voice coil with generally resistive loads and only few complex parts.

The special feature of the combination of a balanced amp with a balanced headphone is the superb channel separation. I want to state that also the channel separation of “normal” headphones and amps is much better than most program material. So there are not many complaints about – maybe because most users don’t know about the better way... Sometimes even the high channel separation of normal amps is perceived as not normal and reduced artificially by “cross-feed” circuitries.

But the optimized channel separation and low intermodulation are often responsible for the “wow” feeling which many first-time listeners have with balanced headphones.

To say it in a striking manner:

Hearing with loudspeaker is like sitting in the audience, hearing with headphones is like taking the place of the conductor. Hearing balanced means being part of the orchestra.

Another technical gain is that you must not use the crappy phone jacks and sockets no more which partly have dramatic influences on the distortion.

But also the use of 2 x 3-pin XLR connectors seems to be not very rational.

We from Lake People / Vioelectric voted for a 4-pin female connector as the output socket.

With a pin-out which is kind of common since the days of good old AKG K1000.

Not according to the general XLR standard but also common is that the female connector is attached to the devices while the male connector is attached to the headphone cable.

A question left is which headphones may be modified easily for balanced operation:

Generally spoken nearly all headphones with cables attached to both ear pieces.

For most headphones with the cable attached to the left earpiece there are more efforts necessary.

Here a list of those headphones where modifications may be applied or not:

AKG: K701 possible

AKG: K702, K712, K812 not possible !!

Audeze: possible for all headphones, partly equipped with balanced connectors ex works

Beyerdynamic: T1, T5, T5P possible

Beyerdynamic: DT 880 not possible !!

HiFi Man: possible for all headphones, partly equipped with balanced connectors ex works

Sennheiser: HD 600, HD 650, HD 700, HD 800 possible

Ultrasone: Edition 8, Edition 10 possible