

Balanced vs Single Ended

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"Balanced" is a term that crops up frequently nowadays. A lot of manufacturers are now fitting Balanced inputs and outputs to their equipment, and there is a lot of talk in the hifi press, too, about the advantages of using Balanced interconnection.

Basically, when you have to transfer a signal from one place to another, you need two wires to do it (current has to be transferred from the output stage of the source component to the input stage of the following component, and this necessitates a loop consisting of two wires). The traditional way of doing this in "domestic" audio equipment is to "send" the signal down the inner core of coaxial cable and to let it "return" via the outer braided sheath, which also happens to be connected to the earth of both pieces of equipment (of course, any talk of "sending" and "returning" alternating current, such as music, is purely to simplify the description).

This method of connection is termed "Single Ended", and has the virtue of simplicity. A simple output stage is needed in the source component and a simple input stage in the receiving component. The single wire used to "send" the signal can easily pick up interference from external sources, and so is "shielded" by the earthed signal "return" braid which surrounds it

A side effect of this method of connection is that, because the "earth" or "ground" (choose your term, they're equally naff) of both units are linked by the same outer braid that also carries the delicate signal, any currents which are tempted to flow between the two because of small leakages in the power supplies of the units, or because they are both connected (separately) to mains earth, will be indistinguishable from the signal and become superimposed on it, generally in the form of a raspy hum and/or greater noise level.

This is the huge drawback of Single Ended, or Unbalanced, methods of connection, and the reason why professional users, such as studios and broadcasters, who frequently have to link together many separate pieces of equipment, have used Balanced for many years - they simply couldn't afford the mess of hum and noise which would otherwise occur. They also originated the chunky "XLR" balanced connectors which are designed to take a "kicking and a half" from "highly trained monkeys"! XLR connectors are also cleverly designed so that they can be plugged and unplugged without causing 'speaker popping hums and cracks, and latch firmly when engaged.

So what is "Balanced"; what does it involve, and what are the pros and cons?

Again, two wires are used, but this time instead of one carrying the (varying) signal surrounded by one bearing the (constant) earth, both of them carry the varying signal, except one carries a "mirror image" (180 degree out of phase) signal. Both wires are identical, usually twisted together, and there is no earth connection between the units. The wire carrying the actual signal is normally termed "+", or "non-inverted", and the wire carrying the phase inverted signal is normally termed "-", or "inverted". It might clarify the concept, to say that "phase inverted" means inversion of "plus" and "minus" voltages and currents - an exact mirror image. I'm sorry, it's very difficult to explain more simply than that!

Both pieces of equipment need to be more complicated with Balanced; the source component has to generate an inverted copy of the signal and send it along with the usual, non-inverted, signal, and the second unit has to have an input stage capable of accepting the inverted and non-inverted signals and recombining them back into one signal. In the old days, transformers were used both at the input and output of most pieces of equipment, and it's very easy for a transformer to generate or accept balanced signals. Since transformers are no longer in vogue, more complicated schemes are implemented using transistors. Generating a balanced output can be particularly troublesome; most manufacturers simply "bolt on" a phase inverter stage fed from the main, non-inverted, output, to provide the phase inverted output.

So, Balanced connection gets rid of the need to link equipment earths and hence eliminated hum and noise loops. But, it has another big advantage too. You see, when the two signals are recombined in the input stage of the equipment being fed, they are recombined by subtraction (the inverted signal is subtracted from the

normal signal, or for the mathematical minded, $[x-(-x)=2x]$). The result is to retrieve the original signal (at double strength) and, this is the clever bit, to exactly cancel out any hum or noise picked up on the wires!

Now you probably understand why Balanced involves sending an inverted version of the signal along with the original. It's because the subtractive process used at the far end neatly subtracts away all common noise picked up on the wires, whilst leaving the signal intact. This means, you can even get away with long runs of unshielded, twisted, cable for Balanced use, although in practice, the cable is often shielded as well to reduce any residual noise even further (and to prevent radio frequency pickup - something balanced alone can't do).

So, is Balanced the great "Holy Grail" of Audio? Is it the "thing to aim for", the essential ingredient for a "top end" system? The advantages outlined above would seem to give it a huge head start over "Single Ended". Unfortunately, things are not as simple as they look; or to put it another way, "there's no such thing as a free lunch"! The problems lie both in the way the inverted part of the balanced signal pair is generated, and the way it's recombined at the far end. As outlined, both involve extra complication in the circuitry, and this can sometimes mean degraded sound quality. Also, regardless of the exact method used to generate the balanced pair of signals, and to reconstruct the original afterwards, the balancing will only extend up to a certain frequency limit - beyond this limit, the signals will no longer be a mirror image of each other, and asymmetry will set in. This can be quite a high frequency, well above the "audible range", yet can still affect the final audible result. And, obviously, if the balancing/unbalancing no longer works perfectly, neither does the noise cancellation which can break down at ultrasonic frequencies leading, again, to audible results.

There you have it. In a lot of cases, where there is a Balanced and an Unbalanced option for connection, the Balanced will be clearly better, often sounding "cleaner" and "purer". And yet, other equipment clearly does not benefit from use of the Balanced option, the Single Ended sounding better. It plainly depends on how well the extra circuitry has been implemented, and whether the resultant benefits outweigh any problems with interference and earth-loop noise and hum from Single Ended. After all, with careful design, careful earthing arrangements, and good screened cable combined with a low driving impedance, traditional Single Ended connection can still be superb and almost totally noise-free.