THE TRUTH ABOUT BALANCING

Mr. Manuel Huher,
President, FM
Acoustics,
Switzerland

Please refer to page 70 for author's biography

Not everything that has XLR connectors, 2 signal lines and a shield is balanced.

The basic goal of signal transmission is to transfer the signal from a source to a load with no loss and with maximum fidelity. Major aspects for optimal signal transfer are:

(a) minimize signal losses in the line
(b) perfect shielding
(c) elimination of hum, noise and interference signals that could be induced into the interconnect cables
(d) minimize crosstalk
(e) adequate surpression of ground potential errors

The idea of balancing sounds simple: use two opposing polarities of the original. The positive polarity version is sent through the positive line and the opposite is sent through the negative line. When these two signals are recombined in a precision differential summing input stage, the original full level signal is recovered while common mode noises, interferences, hum, etc. are surpressed (these unwanted signals enter both lines symmetrical and therefore can be rejected).

In additon crosstalk will be reduced dramatically because:

(a) only half of the original peak level signal is sent down each line and
(b) there is self-cancellation of two closely coupled but opposite polarity signals.

A truly balanced circuit must be totally symmetrical ("balanced") in relation to ground.

The technical term that describes the accuracy of the balancing is the "Common Mode Rejection Ratio", in short "CMRR". This value indicates how well the circuit will reject unwanted signals that enter both lines symmetrically, (e.g. hum or noise). The higher the CMRR value, the better the balancing of the circuit and the less negative effect interference signals can have. The CMRR values of existing so-called "balanced" equipment is as low as 30-60dB, a disappointing result not really warrantying the terms "balanced" or "symmetrical". Such low CMRR values are not acceptable as the circuit and the lines are not well balanced at all. For decent performance a CMRR of 80-100dB is required and this must be so over the full frequency band. However in reality many of the existing circuits show poor performance at the critical low- and high frequencies.

What also must be avoided are signal currents flowing in the ground paths of the various units. The voltages generated by these ground currents must be common mode voltages. Only then can it be guaranteed that and they have no negative influence on a balanced signal.

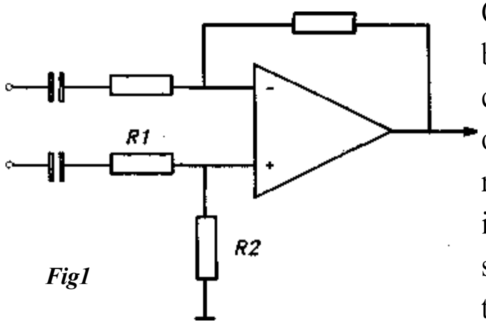
A balanced circuit must porvide two equal but opposite polarity signals, which must be symmetrical to ground. The impedance from positive and negative signal lines to ground must be equal for common mode signals and for normal audio signals.

The above two requirements are met with audio transformers, but transformers have inherent limitations (such as distortion at low frequencies, mediocre transient capability non-linearities and large phase errors) that make them unusable in high accuracy interfacing. In fact, without the users knowing, many transformer-coupled lines are unbalanced by incorrect termination. The frequency response of a transformer is very dependent on the source-and load impedance, and huge errors can appear if these factors are not painstakingly accounted for.

Because of the disadvantages of transformers, there has been a surge of circuits that try to electronically simulate the symmetry of transformers for both input and output applications.

Balanced Inputs

The usual input stages such as Fig.l are only mediocre. These are simple differential input amplifiers and instrumentation amplifier configurations with op amps. The instrumentation amplifier configuration offers reasonable performance in regards to noise, but it entails undesirable voltage followers with potential stability problems and limitations in input voltage swing. Furthermore the input stages are not protected against RF. The other problem is that these circuits often only work properly under ideal circumstances on the test bench but not in the real world where cables of multiple meters with their considerable capacitance and inductance are connected.



Circuits such as in Fig.l offer a little isolation from ground, but it is not sufficient isolation. This circuitry also has other characteristics that are undesirable: the input impedance on the non-inverting leg is permanently defined by the resistor value Rl and R2, while the input impedance on the inverting leg is changing dynamically with the signal. With signal the non-inverting input is of course moving and therefore the reference point for the inverting leg is changing. The impedance it is seeing is changing with the signal as well. The negative input leg impedance is continually varied by common mode voltages and non-differential sources.

One has to realize that these circuits will not perform well at all if the signal source has any significant impedance. The performance is therefore dependent on the source impedance of the preceeding equipment. This means nothing else than that the performance of units with such so-called "balanced" circuitry will change depending on which type of product is connected to the input! Different sources = different sound..., not a satisfactory situation at all.

While instrumentation amplifier circuits can have common mode rejection, they are not ideally suited for audio applications.

Balanced outputs

Typical electronically "balanced" outputs are not at all truly balanced. All that is done in those circuits is that an inverting stage is added (which inverts the output signal by 180° and feeds it to a second signal line, see Fig.2). As two conductors and a shield are now used to transfer the signal, the layman thinks that his system is now balanced.

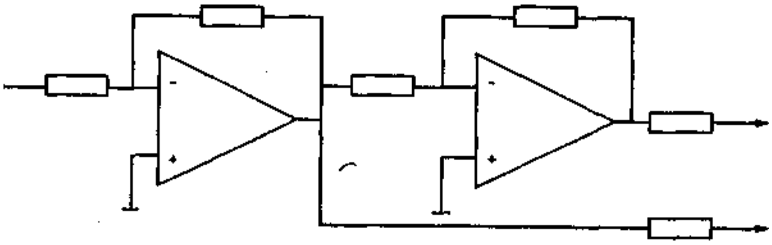


Fig.2

But true balancing requires much more than just the presence of two signal lines!

It is actually not so difficult to detect the more primitive balancing circuits. One of the tests: if the output impedance of an unbalanced output is lower than that of a balanced output, it is likely that a simple phase inversion circuit is being used in the product.

The floating test

Whatever the common mode potential, the differential output potential must not change. Furthermore, the output must be able to accept and stably drive any load (even if unbalanced) and this must be so even to the extent of shorting either signal line to ground. This is what in the professional field is called the "floating test": when one signal line is shorted to ground there should be absolutely no influence whatsoever in the other leg.

As an example the circuit in Fig. 2 fails the floating test, since if one leg is shorted to ground, the overall output will drop by 6dB. One must also realize that there are nasty effects happening when a shorted amplifier is delivering current into the ground. Almost all equipment that is currently marketed as "balanced" will fail the floating test.

Whenever an output impedance rating reads something like "Balanced 600 Ohms, Unbalanced 300 Ohms", the product very likely just has a simple 180° phase inverter added to the unbalanced output. This is not a high performance symmetrical or "balanced" output and will certainly not give the same performance as a truly non-compromised balanced output! In order to attain a truly balanced output stage, much better balancing than a simple phase inverter can provide is required.

A major problem area of balanced output circuitry is stability. Most of the popular circuits are right on the edge of instability. Tolerances of parts help to bring these circuits close to instability when they drive real-world impedances and cables. As is the case with other audio products, plenty of reserve in phase margin, stability and drive capability is required. It is such care to details and the elimination of part tolerances that sets a superior product apart from a mediocre so called "balanced"one.

Of course balancing requires the correct interconnect cables. They play a very important role. Most currently available audiophile interconnect cables are not true balanced cables (even if they have XLR connectors...) and optimal performance cannot be reached with such cables. In a balanced interconnection there is a number of additional requirements compared to cables used in unbalanced circuits. Of course shielding is of high importance but there are a variety of other characteristics that must be taken into account as well. FM ACOUSTICS has printed a Technical Bulletin on the selection of the correct interconnect cables.