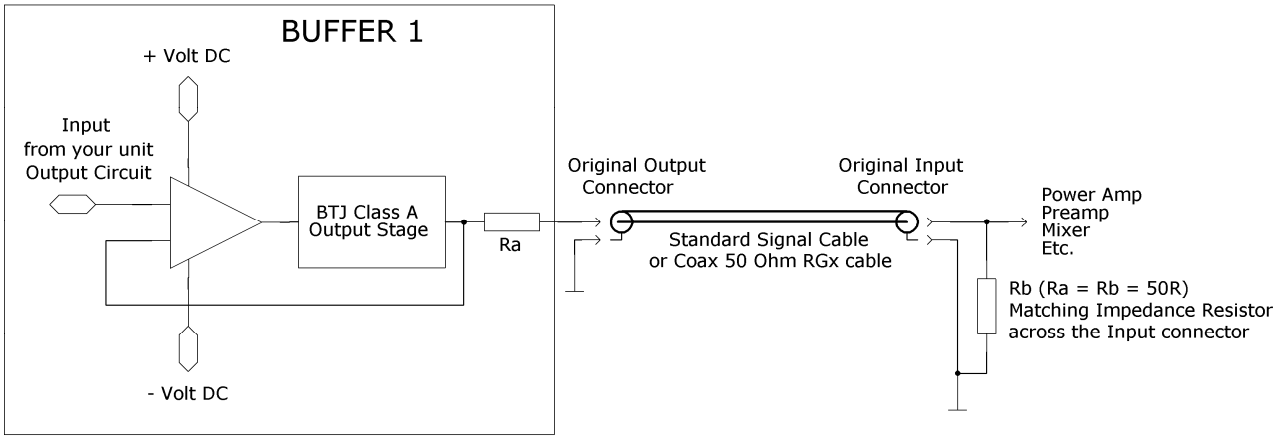
Theory and facts about Impedance Buffers

Last updated 14.04.2008

Why use Impedance Line Level Buffers?



We will here try to explain, why it is so important to use Impedance Line Level Buffers in Signal Transmission Lines (afterwards referred to as STL).

Many people claim that STL has no effect in the Audio Band range from 20 to 20,000 Hz. Some of these critics are manufacturer of High End Audio grade cables, however as you will discover here, is that the effect of using Audio grade cables together with the STL principle can improve both even more.

As you will learn later in this "white paper", pure sine waves in the Audio band can't be compared to the real complex signals in the real world of High Fidelity music reproduction.

Input and Output Impedances

The basic idea underlying the STL stems from the recognition that the typical maximum signal amplitude from an audio source, say a Tuner or CD player is of the order of four volts or less (normal Line Level input to a Power Amp for max output is from max 0.7 to 1.4 Volts). Moreover, the input impedance of the receiving unit such as a Preamplifier or Power Amplifier is often in the order of 47,000 Ohms or greater.

Under these conditions the signal Current through the interconnecting cable would under normal conditions be max 3mA and more often less. This is to be contrasted with the current, which flows from the output of a typical Power Amplifier to a Loudspeaker with a power capability of 100 watts or more. In this latter situation the signal Current flowing through the speaker cable can be as much as 10 Amperes or more.

Literally there are dozens of suppliers of CD Players, Turntables, Microphones, Interconnect cables, Preamplifiers, Power Amplifiers etc. Moreover, there is no industry wide standardization of input and output impedances of these products that must be interconnected. For example, a random survey of the output impedances of CD Players from several manufacturers showed a range of from 20 Ohms up to 1000 Ohms. Similarly the input impedance of a group of Preamplifiers went from a low of 47,000 Ohms up to 1.000,000 Ohms. In the last case, their will only flow 0.14uA in the interconnect cable at max output!

Theory and facts

All cables have an unavoidable leakage capacitance that increases in direct proportion to their length. This manifests itself in a "low-pass" filter characteristic which may cause a signal "roll-off" within the audio band in interconnects longer than a few meters and driven from a relatively high impedance source.

Under particular operating conditions an interconnect can function as an antenna picking up radiated electromagnetic signals from such low frequency noise sources as household appliance motors and fluorescent lighting systems. Under certain other conditions high frequency signals from radio transmissions and computer systems also cause signal corruption.

It is well known that the more robust a current signal flowing through an interconnection cable is, the less it is subject to corrupting external noise sources. It is further theorized that a much more robust current signal is less subject to distortions created by known electronic conduction deficits within the cable itself due to material impurities and atomic structural irregularities. It is believed that these atomic level irregularities cause random distortions to the desired audio signal, and which, although very small, are nevertheless detectable to the listener due to the extreme sensitivity and dynamic range of the human ear.

It is also well known that maximum energy transfer between an electrical energy source and the load it is driving occurs when the impedance of the load is exactly equal to the impedance of the driving source. Ohms Low states that.

Of great importance in some audio applications is the fact that these results hold true independent of the cable's length. It should also be noted that a well-designed audio cable is an excellent approximation to a loss-less cable. That is to say its series resistance is very nearly zero and its shunt resistance is practically infinite.

There is a further advantage to terminating a cable in its characteristic impedance that is very important: A cable properly matched with its characteristic impedance at both its source and receiving ends transfers the maximum amount of available electrical energy between the source and the load. Such a cable also behaves as a reflection-less and distortion-less line, since no net energy per cycle is capacitive or inductively stored along the length of the cable.

In situations where the signal source is a sinusoid of fixed amplitude and frequency any mismatch between the characteristic impedance of the cable and its terminating impedance manifests itself as a simple phase shift between the input signal and the output signal. However, a signal that represents music, voice or other non-recurring analog waveform presents a much different problem. These signals are made up of mixed signal sources, complex waveforms of varying amplitudes, frequencies, and their harmonics, that are interrupted with pauses of varying lengths. Thus, in the case of music, any excess capacitive or inductive energy stored in the cable discharges itself into the load impedance in an unpredictable fashion. When these signals are translated into sound, the listener hears them as a dulling, smearing or loss of articulation in the music.

The STL Buffer Solution

After much experimentation, it has been found that a dramatically improved audio listening quality is achieved when the signal current flowing through a cable between a CD Player or other Line Level audio source and the Preamplifier or Power Amplifier is increased by several orders of magnitude. Typically, this means increasing the signal Current from tens of uA up into the range of tens of mA. It should be understood that this current transformation is intended to take place without in any way modifying the Voltage amplitude of the original signal. That is to say that a signal power gain of thousand or more is achieved while maintaining unity gain of the originating Voltage signal.

From a listening standpoint when this transformation has been implemented, it is found that there is a great improvement in overall listening clarity, as well as better "sound staging" that are audio separation of multi-voices and instruments. This is particularly true in the mid frequency range of the audio band where the human ear is especially sensitive.

The Amplifier circuit is designed such that it is capable of delivering a power gain greater than one thousand while still maintaining unity Voltage gain and without introducing any audible distortion. By design the output impedance of this amplifier is made equal to the characteristic impedance of the cable to which it is attached. The impedance we have chosen is 50 Ohms (but anything between 25 and 100 Ohms could have done the trick) and the overall length of the interconnecting cable ranges in length from ½ to 25 meters or more. At the receiving end of the interconnecting cable a terminating resistive load is incorporated into the cable plug or inside the unit. This termination load is also chosen to be equal to the characteristic impedance of the Buffer output. Also, connected to the interconnection cable at its receiving end is typically a Preamplifier or Power Amplifier. The input impedance of such devices are typically 47,000 Ohms or greater. In any event this input impedance has negligible effect when paralleled with the low terminating resistance of the cable.

By way of example a CD Player with a peak signal amplitude of plus or minus 4 volts operating into an Preamplifier/matched-cable STL combination with a characteristic impedance of 50 Ohms will have a peak current flowing through the cable of 80 mA.