

## Ground Loops - and how to deal with them

By Daniel Collins

The most common cause hum in any audio system is a phenomenon known as a ground loop. A ground loop occurs when the power supplies of several components are connected to grounds of different potential. Since all solid state circuits operate on direct current and the power in our wall outlets is alternating current, the power supply of any such component performs a function known as rectification. Rectifiers convert alternating current into direct current in different ways (see illustration 1). What all rectifiers have in common, is that they do not produce a constant direct current, but rather one that fluctuates slightly. This fluctuation is in time with the frequency of the alternating current source (60Hz in North America, 50Hz in South America and Europe). In either case, this is right at the low end of the audible sound spectrum. It is the passing of these "vibrating" voltages through various audio amplification circuits on their way to ground that causes the characteristic ground loop hum.

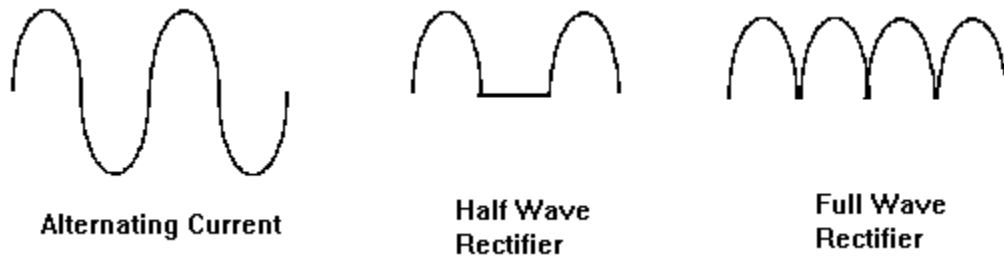


Illustration 1 - Rectifier output

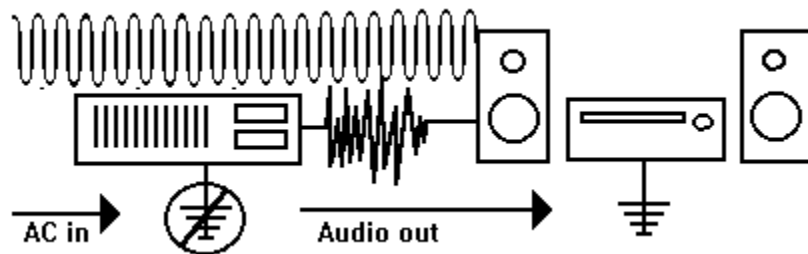
Electricity, like water, always follows the path of least resistance (ie. it flows down hill). This has the effect of having all current in a circuit flow towards earth ground (from this point on I will use the term earth to indicate earth ground - the green wire in your outlets - as opposed to circuit ground - the white wire in the outlet). If everything is designed and works correctly, then all the components in your audio system will have properly earthed power supplies and you will never hear a ground loop. However, in the real world, amplifiers tend to be the only audio component that are usually equipped with earthed power cords. This situation creates the ideal environment for ground loops to occur. Why, you may ask, if this situation is so common, have I never encountered this problem before? In reality, you probably have and do not know it. Many sound systems operate with a ground loop, but the level of the hum is so low as to be inaudible. Only when the amplification factor is very large - such as in the phono inputs - is the ratio of the hum

signal level to the audio signal level high enough to be detected (which is why turntable often have "ground" screws on their backs).

This situation is altered when a computer's sound generation adapter is attached to the sound system. The voltages used in most audio circuits are typically around 5 volts. In a PC, there are also 12 volt components. The result is that the hum level is over twice as loud as between other components of the stereo. Added to this problem is that PCs are not designed to be quality audio components. Their power supplies and the various circuits within the PC (which includes your sound card) all use a common ground point, the chassis which is connected to earth. This results in all the power generated and consumed inside your PC ending up on the common, or ground, side of your audio outputs. When this signal is amplified, the result can be a very pronounced hum.

So, how do we deal with this problem without rewiring our PC power supply? Several different approaches are possible, depending on the severity of the problem.

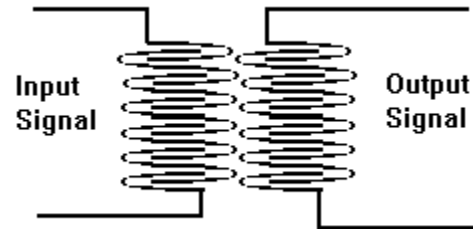
First and foremost, make sure that both the PC and the sound system are connected to properly wired outlets, preferably on the same circuit. Do not assume that your outlets are correctly wired. Many homes have various wiring errors, most commonly the neutral and earth connections are reversed. A small plug in device, available at most hardware stores or electronics stores (like Radio Shack) will visually confirm that the circuit wiring is correct. Many ground loops will be eliminated this way. Since all components share the same ground, all signals will flow to earth within a single component.



**Illustration 2** - If the earth on the computer is not as thorough as the amplifier's then a 50/60 Hz signal will pass through the audio outs to the amplifier.

Some cases of ground loops will not be cured by the above fix, because the internal connection to earth is not complete in one or more components. So, although they all share the same earth connection, the "downhill" path still runs through an audio connection. In these cases, the easiest solution is to invest in a pair of "isolation

transformers". These devices take advantage of the fact that audio signals are alternating current. When AC flows through a coil of wire, it produces a magnetic field that fluctuates in synchronization with the AC signal. In addition, a coil that is placed in a fluctuating magnetic field produces an AC current that is in synch with the field's flux. So, it is possible to pass an audio signal from one device to another with no physical electrical connection. With no connection, no ground loop.



**Illustration 3** - An isolation transformer

Finally, you may not have a very efficient earth connection. Although this not usually the cause of a ground loop it can be the cause of hum resulting in the AC neutral (where a VERY strong 60Hz signal resides) being used as the circuit ground of your audio system. This signal can feedback into the audio system and cause various buzzes and hums. While a volt meter will indicate any voltage flow from earth to neutral, this is not a test to be performed by individuals that are not experienced in dealing with 110/220 volt electrical circuits.