VintageVibe guitar pickups

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In many of the email messages I receive people express an interest in eliminating noise they hear when playing electric guitar. Noise and the elimination of noise is the topic of this article.

In this newsletter my intent is to provide useful information about the source of noise and methods that can be used to reduce or eliminate it. Here's my disclaimer: the information presented here is based on my personal experience and what I have learned from others over the years. Please let me know if you disagree with any technical aspect presented here or if you have found any alternative methods for reducing noise- I would like to hear from you!

One more disclaimer: I use the term "eliminate" in this article; in my use of this word I intend to describe the reduction of noise to such a low level that the noise is no longer an annoyance. It is unlikely one would ever eliminate 100% of the noise signal.

Back to the issue of noise…

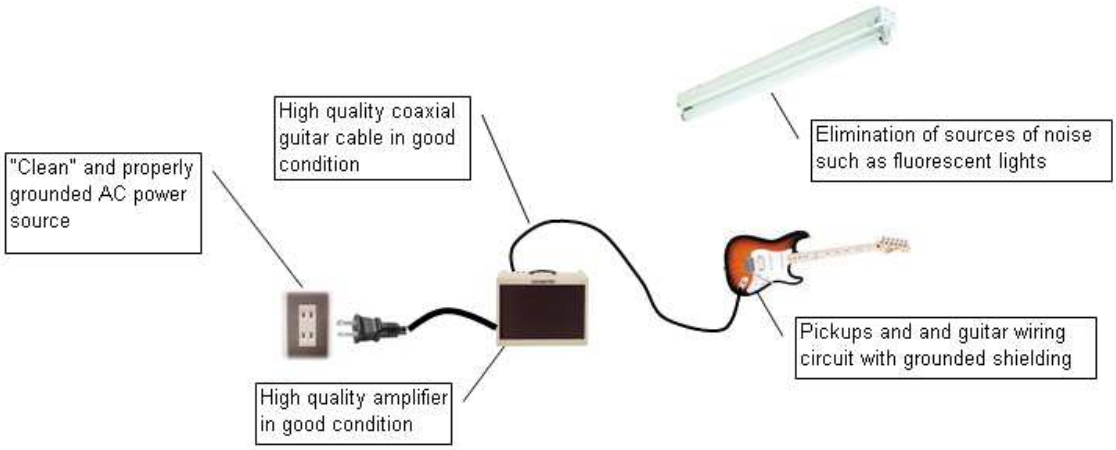
The noise I am focused on in this article can sound like an old electric shaver and is very annoying.

Pickups and the tone & volume control circuits in a conventional electric guitar such as a strat, tele or Les Paul are very good at "picking up" electromagnetic radiation from nearby devices that utilize alternating current (AC) electric power. Passive (un-powered) pickups can have 5,000, 10,000 or more turns of wire in the coil. Such a coil can function very effectively as an antenna to receive noise from sources in the environment. Sources of AC interference include florescent lights, power transformers and dimmer switches. The fundamental frequency of this noise is 60 Hertz (abbreviated HZ and represents cycles per second). Noise from devices powered by AC electricity may also contain higher frequencies that are multiples of 60 Hz (120 Hz, 240 Hz and so on).

Over the years very clever folks have put significant effort into minimizing noise.

There are typically three approaches:

1. **Reducing noise at the source**
2. **Shielding from the noise source**
3. **Reducing noise at the "receiving end"**



To get the lowest noise possible one must think of the whole system: the electromagnetic environment (noise sources), guitar, guitar cable, amplifier and the AC power supply.

Let's take a look at each of these approaches separately.

1. Reducing noise from external sources

Devices operated with AC electric power such as florescent lights, track lighting (which use transformers), electric motors and other items radiate electromagnetic energy in all directions. This radiated electromagnetic energy is easily received by the pickups and the wiring circuit in an electric guitar. Eliminating these "sources" of AC induced noise can go a long way towards reducing hum heard through an amplifier. Recently my wife asked me to install ceiling mounted low-voltage track lighting in the room where I practice; the first time I played my guitar through a Fender Hot Rod Deville with this track lighting on I noticed a significant amount of hum. Turning off these lights made the hum go away. After thinking about it I concluded that the powered track may be an excellent antenna for broadcasting electromagnetic radiation from the transformer that powers the lighting system. I now use a standard incandescent lamp in this room and experience very little noise when playing my electric guitars. Magnetic fields can also induce noise in electric guitars, but the good news is that magnetic fields tend to fall off in intensity in short distances. Another potential source of noise is from static electricity. In the winter during periods of low humidity is when the presence of static electricity is most obvious.

Another important thing to check is the electric power outlet the amplifier is plugged into. If the outlet is improperly grounded or has other wiring issues noise will be a problem. I use an outlet tester as shown in the photo below.

This type of outlet tester is available in many hardware stores and costs ~ $8 to $10.

When plugged into a properly wired outlet the tester will indicate the circuit is good as shown below:

During the winter I spray the carpet where I practice with an anti-static spray such as Static Guard; this virtually eliminates the “pop” and “hiss” that can be caused by static electricity generated when my shoes move across the carpet.

Static guard costs ~ $3.50 a can and is available in many stores including Walgreens.

2. Shielding from noise

Use of an undamaged high quality coaxial shielded guitar cable to send the signal from an electric guitar to an amplifier is essential to eliminating noise. Wireless systems introduce yet another possibility for the introduction of noise and will not be discussed in this review. It is also a good idea to check that the amplifier itself is free of unwanted noise. To test for this, insert a guitar cable into the amp with the other end of the cable not plugged into an instrument. Turn on the amp and listen for noise as the volume and gain are increased. Please note that the free end of the guitar cable should not be in contact with any conducting or partially-conducting surface (such as your hand) during this test. If your amplifier makes noise during this test no amount of work on the guitar or other components of the system will eliminate the noise. A noisy amplifier should be serviced by a qualified amplifier technician to eliminate the cause of the noise and to ensure there are no safety issues.

Proper grounded shielding in the circuit of an electric guitar can be very effective in eliminating unwanted hum caused by external AC electric fields.

The history of grounded shielding dates back to the 1800's and is attributed to Michael Faraday[1]

Michael Faraday, (1791 –1867) was an English chemist and physicist who contributed significantly to the fields of electromagnetism and electrochemistry. It was largely due to his efforts that electricity became viable for use in technology. The SI unit of capacitance, the farad, is named after him.

In his work on static electricity, Faraday demonstrated that the charge only resided on the exterior of a charged conductor, and exterior charge had no influence on anything enclosed within a conductor. This is because the exterior charges redistribute such that the interior fields due to them cancel. This shielding effect is used in what is now known as a **Faraday cage**.

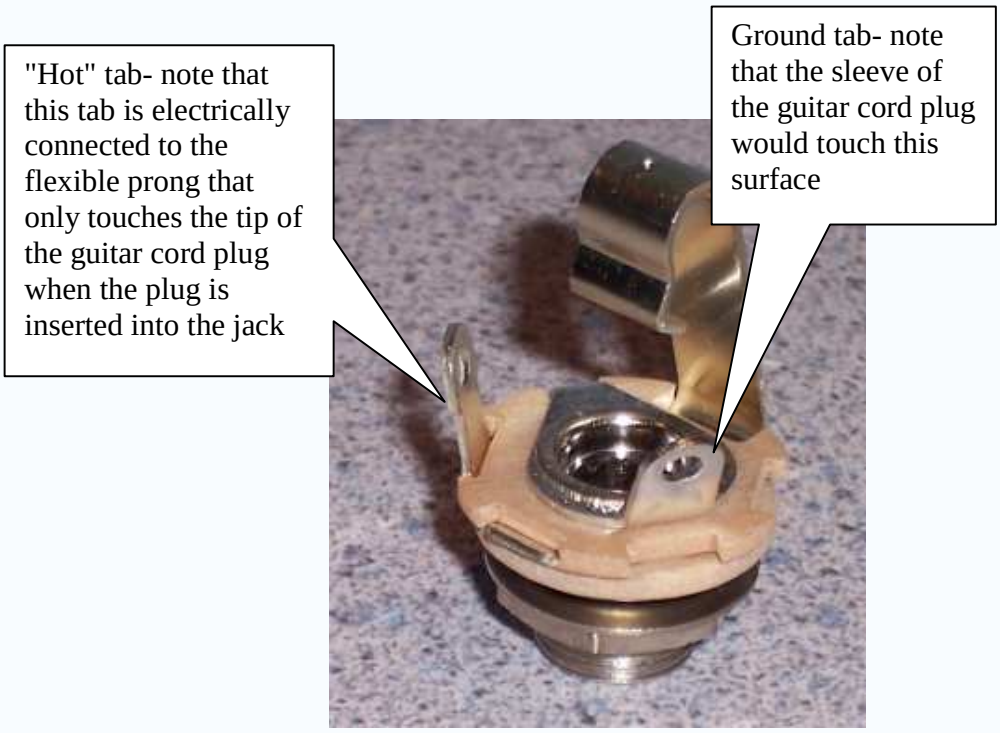
A **Faraday cage** or **Faraday shield** is an enclosure formed by an electrically-conducting material. The electrical charges in the Faraday shield repel each other and will therefore always reside on the outside surface of the shield. Any external static electrical field will cause the charges to rearrange so as to completely cancel the field's effects in the cage's interior. This effect is used to protect electronic equipment from lightning strikes and other electrostatic discharges.

To a large degree, Faraday cages also shield the interior of the enclosure from external AC electromagnetic radiation from “noisy” sources such as florescent lights, transformers and electric motors. The faraday cage must be connected to a good electrical ground to function.

In an electric guitar it is common to line the inside surfaces of the controls cavity and even the pickup cavities with copper tape. Each panel of copper tape must be in good electrical contact with the ground connection of the output jack of the instrument. Unless otherwise requested, I put grounded shielding in the pickups I make. When the pickups are properly shielded no additional shielding is required in the pickup cavities. Shielding does add capacitance to the guitar circuit. The effect of this added capacitance can affect the tone of an instrument. When a significant surface area of shielding (more than 10

square inches of surface area) is added to an instrument the treble frequencies will be affected in the same way a tone pot removes treble.

Be aware that it is possible to wire the output jack of an electric guitar backwards; if this is done the grounded shielding will not function and a potentially dangerous situation may be present.



Output jack used commonly used in an electric guitar

3. Eliminating noise

Several approaches have been developed to eliminate noise in electric guitars: humbucking (or hum-canceling) pickups, “active” pickup systems and “noise gates”.

Seth Lover's famous **humbucker** design (U.S. Patent 2,896,491) was the P.A.F. (Patent Applied For) which he designed while working for Gibson Musical Instruments in 1955. Humbucking pickups are comprised of two coils connected electrically in series that are reverse polarity, reverse wound (RWRP) with respect to each other..If one coil is wound clockwise and has a magnetic field polarity that is north up, the other coil would be wound counter clockwise and its magnetic field would be south up. The signal induced in one coil from the vibrating strings of a guitar has a waveform with a specific phase angle. In the second coil the waveform is changed 180 degrees by the opposite winding

direction and another 180 degrees by the opposite magnetic field direction. These two 180 degree changes sum to a 360 degree change and the signals from the two coils are in phase and add together to give a powerful signal. Noise from external AC electric fields enters both coils, but this noise is unaffected by the magnetic fields of either of the two coils. The noise in one coil of a humbucker is 180 degrees out of phase with the noise in the other coil. These two noise waveforms interfered destructively and cancel each other eliminating the noise.

“Active” guitar systems typically involve the use of pickup coils with fewer turns of wire (and often wire of larger diameter) and weaker magnets. The “raw” signal from coils designed for use in active system is amplified by a circuit inside the guitar powered by a 9V DC battery. These active systems may also include filters to further reduce noise.

A **noise gate**[1] is an electronic device or software logic that is used to control the volume of an audio signal. They are commonly used in the recording studio and sound reinforcement. Small portable units are also used by rock musicians to control unwanted noise from their amplification systems. Band-limited noise gates are also used to eliminate background noise from audio recordings by eliminating frequency bands that contain only static.

In its most simple form, a noise gate allows a signal to pass through only when it is above a set threshold: the gate is open. If the signal falls below the threshold no signal is allowed to pass: the gate is closed. A noise gate is used when the level of the 'signal' is above the level of the 'noise'. The threshold is set above the level of the 'noise' and so when there is no 'signal' the gate is closed. A noise gate does not remove noise from the signal. When the gate is open both the signal and the noise will pass through.

More advanced forms of noise gates have more features. Most common is the ability to control how quickly the gate will close once the level has dropped below the threshold. This is known as the *release*, and allows for a smooth decay rather than an abrupt cutting of the sound when the gate closes. Likewise the ability to set the time it takes for the gate to open is available on some gates. This is known as the *attack* control. If the attack time is too short a click can be heard when the gate opens. Sometimes there is a *hold* control. After the gate opens, the hold time determines the minimum time the gate will stay open. When used with a speech signal, the hold time can prevent the gate from closing during short pauses between words or sentences.

The amount of attenuation when the gate is closed can be set by the range control. Often there will be complete attenuation; that is no signal will pass when the gate is closed. In some circumstances complete attenuation is not desired and the range can be changed.

Well; that’s it for now; I hope this has been useful for you.

Pete Biltoft

Vintage Vibe Guitars

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[1] Wikipedia http://en.wikipedia.org/wiki/Main_Page

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