Understanding Guitar Wiring

How a magnetic pickup works

Through the process of inductance, an electrical current is generated (see generator) in a coil of insulated wire, which is then sent to the amplifier. If you have a coil of insulated wire wrapped around a magnet you create a simple generator. If the magnetic field of the generator is held in proximity to an oscillating (vibrating) ferrous material, then an alternating (or AC) electrical current will be generated. Conversely, if you wrap a coil of wire around a ferrous material, a nail, for example and apply an electrical charge to that coil, the ferrous rod (the nail) will turn into an electromagnet.

One misconception that a lot of people have is that the guitar amplifier is sending a current to the guitar—this is not true. A cable plugged into a guitar amp will not shock you—unless there is a severe grounding problem with the amp! The pickup generates an AC signal and sends it to the amplifier, via the various pots and switches. The amplifier then takes this weak signal (measured in millivolts and typically never exceeding 2 volts) and through a series of gain stages, boosts the signal to a voltage and amperage that can drive the speakers.

The specific parts and their purpose

The Bobbin and Frame

Different types of pickups have different bobbin and/or frame construction. Traditional or vintage-style Fender single-coils have the simplest construction with polepieces pressed directly into the flatwork. Humbuckers and other single-coil pickups have a molded plastic bobbin to accept ferrous slugs, adjustable polepieces or screws, or permanent-magnet polepieces, depending upon the design of the pickup. Humbuckers also utilize a metal frame (usually brass so that it doesn't affect the magnetic field), to which the various components attach.

The Coil of Copper Wire

The pickup coil-wire or magnet-wire is wrapped around the bobbin assembly. The fine wire is either machine-wound or hand-wound depending upon manufacturer specs or the desired tone. The 42 or 43-gauge wire must be handled very carefully, as it's very thin and fragile. Different pickups utilize more or less turns of copper wire. This is one way that manufacturers can change the output and tonality of a pickup design. Coils generally have anywhere from 6,000 to 8,500 turns of wire.

The Magnets

Depending upon the design of the pickup, magnets come in a wide variety of shapes and sizes. Magnets can also be made from various permanent-magnet materials, such as AlNiCo and ceramic.

The differences between single-coils and humbuckers

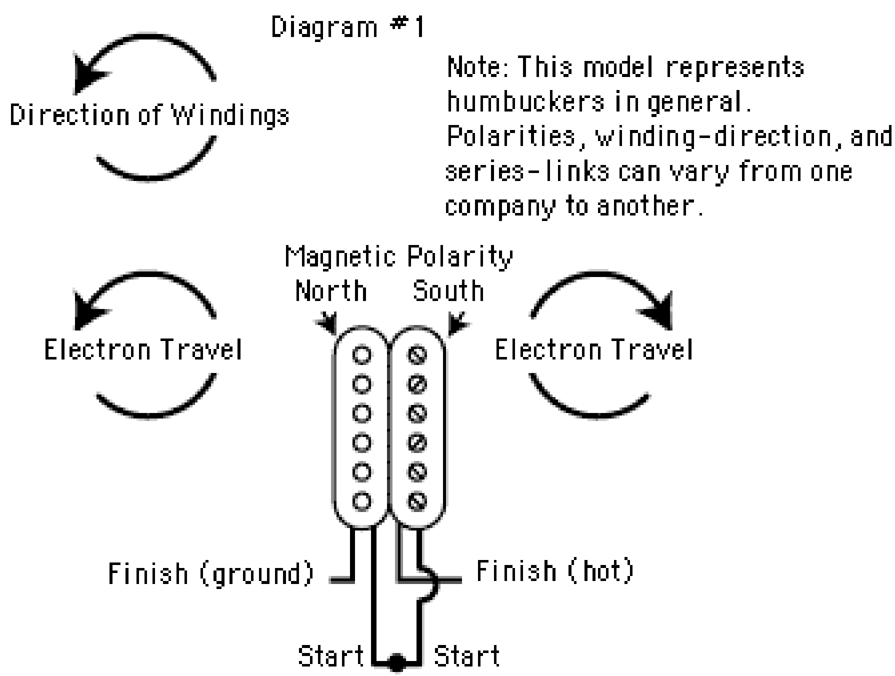
There are many differences between single-coil and humbucking (hum-canceling) pickup designs—everything from inherent tonal qualities to their size and shape. A humbucker must have two coils that are wired to that they effectively cancel 60-cycle hum. To achieve this cancellation in the traditional sense, the coils must have opposite magnetic polarity and are wired electrically out-of-phase.

A pickup is simply an antenna. A single-coil pickup is nothing but a big antenna for hum and RF interference. When two coils of the proper magnetic polarity and electrical phase are combined, they will effectively filter out RF interference without canceling the output or sound of the pickup. This is a humbucker!

Understanding 4-conductor pickups

To understand a 4-conductor pickup, we must first study a single-coil pickup since a humbucker is simply two single-coils combined as one pickup. A single-coil is comprised of three primary components: magnet(s), the coil that has a "start" and a "finish" and the bobbin. Think of a single-coil as a 2-conductor pickup—the start and the finish. When a single-coil is wired, typically the start is connected to ground, and the finish is hot.

Since a humbucker is two coils each with their own start and finish, we now have four conductors. The four conductors can be wired in a variety of ways. First, the coils can be wired in series or parallel, the coils can be in-phase or out-of-phase with each other. The traditional humbucker is wired in series, out-of-phase (see **diagram #1**). The series link gives a boost to the output (parallel reduces output and gives a more nasal tone), and the out-of-phase correlation acts to cancel the hum.



Coil polarity and phase relationships
Determining a coil's magnetic polarity is very important for achieving hum-canceling combinations of coils from two different pickups. Many humbucking pickups by various manufacturers have the same type of polepieces for both coils. In other instances, you can use a known pickup's coil(s), to see if it repels or attracts the other pickup. Remember, similar magnetic polarities repel each other, while opposite poles attract.

Use the chart below to help determine what the phase relationship will be between two coils. This chart assumes the typical parallel connection—the connection you get with a selector switch.

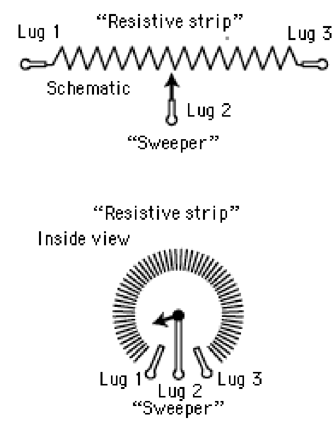
	CW-N	CW-S	CCW-N	CCW-S
CW-N	In phase	Out of phase	Out of phase	In phase, hum cancelling
CW-S	Out of phase	In phase	In phase, hum cancelling	Out of phase
CCW-N	Out of phase	In phase, hum cancelling	In phase	Out of phase
CCW-S	In phase, hum cancelling	Out of phase	Out of phase	In phase

In Phase = The typical (correct) orientation of two coils.
Out of Phase = A thin, nasal output useful for certain styles of music. Don't Confuse the misnomer of the "Strat out-of-phase" sound with this type of coil correlation. The "Strat out-of-phase" sound is actually a typical parallel, in connection. Due to the parallel connection and the distance from one coil to the other, the tone of a Strat's positions 2 and 4 sounds "pseudo" out-of-phase.
In Phase Hum-Cancelling = The two coils are properly used to give the correct sound and their full output, and their polarities are oriented so that they cancel 60-cycle hum.

What is a potentiometer and how does it work?

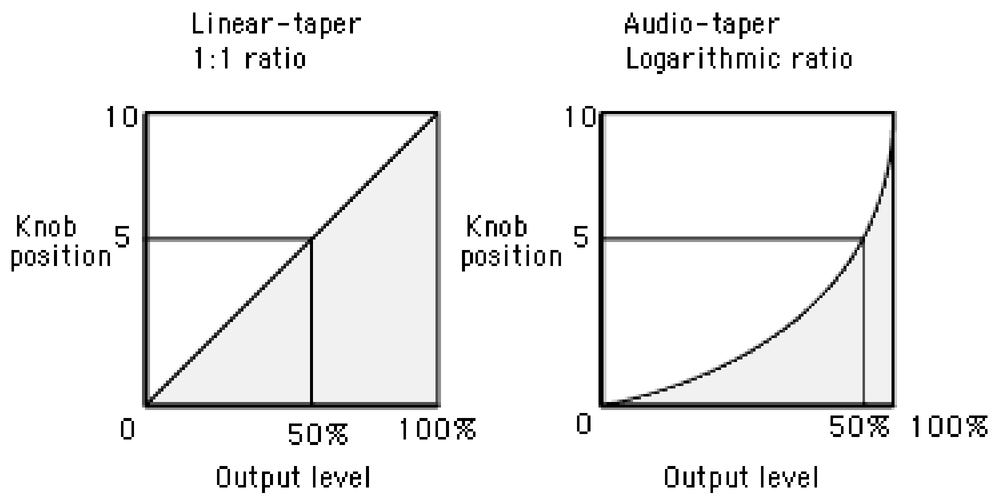
A potentiometer, or pot, is a variable resistor. This means as the knob shaft is rotated, the DC resistance will change. A pot is very simple by design, and once we review the components and their purpose they should be less mysterious. First, there are three lugs or soldering terminals on a conventional potentiometer (see diagram #2). The outside two are the ends of the resistive strip, and the center lug is connected to the "sweeper." The sweeper allows you to vary the DC resistance relative to its position along the resistive strip, or relative to the outer two lugs. If you connect to only the two outside lugs, you will have a resistor of the pots value —25K, 250K, 300K, 500K, and 1Meg are common guitar pots. This is how you can determine a pot's value.

Diagram #2
Potentiometer diagram



Potentiometers come in two varieties, linear-taper and audio-taper. The easiest way to see the difference between the pots is to diagram their tapers (see diagram #3). You'll see that the linear-taper pot's taper works at a 1:1 ratio. Audio taper, has a special logarithmic ratio. Guitars usually use audio taper, because our ears don't hear changes in volume in a linear fashion as you might expect. As the volume increases, a greater change in signal or sound-pressure is required to perceive a smooth transition. Using a guitar's control knob settings as an example, the actual change in volume between 2 and 3 is much less than the change between 7 and 8.

Diagram #3



How is a volume pot wired?

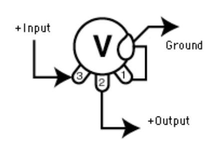
In order to control the volume of an electric guitar, the signal is directed through a pot. When wired as a volume control, the pot allows you to vary the amount of electrical current flowing through it. By sending part of the signal to ground, a volume pot controls the amount of electrical signal the amplifier receives. If the sweeper, which is usually the output of a volume control, is connected to the lug that is grounded (zero on the volume knob), then there will be no output. If the sweeper is connected to the other end of the resistive strip (10 on the volume knob), then the guitar would be at its maximum volume level.

The value of the volume pot used is determined by the guitar's pickup(s) and the preference of the player or builder. Generally, 250K pots are used with single-coil pickups, and 500K pots are used with humbuckers. A higher value pot can produce a brighter tone, while lower values can fatten the tone by attenuating some of the high-end frequencies. This is because that there is always a certain amount of signal going to ground, even at full volume (10 on the knob). High frequencies are the first to go to ground; therefore a lower value pot will allow more of these frequencies to pass to ground, rather than out to the amp as a part of the guitar's signal. Experiment with different value pots to see which ones work best for you.

Typical wiring

Diagram #4 shows a typical guitar pot. The “hot” output (sweeper; lug 2) pans between the “hot” input (lug 3) and ground (lug 1).

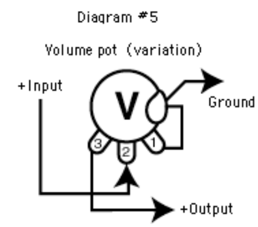
Diagram #4



Reversed (Jazz Bass) wiring for independent control of volume

If a guitar has two or more volume controls that are wired in the traditional manner (a Les Paul for example), an interesting thing occurs when the selector switch is in the middle position. The volume control for the neck or bridge pickup will turn down the whole guitar—not just its respective pickup. Yet, on a Fender Jazz bass, which doesn't have a selector switch, two volume controls somehow allow you to turn the pickups up or down independently, without affecting the output of the other. How is this possible?

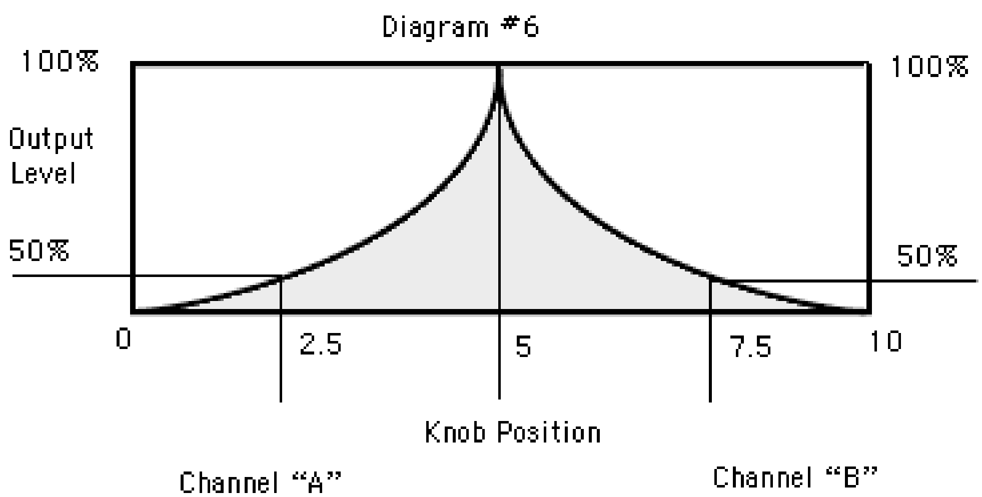
The reason for this is simple. Since the volume controls are in parallel and the output of the volume pots is the sweeper, when either of the controls is turned down (applying signal to ground) the sum output (what the output jack and amp “see”) is “short-circuited” to ground. To resolve this problem, simply swap the input to lug 2 and the output to lug 3.



This means that the output jack or the amp never really see or are shorted directly to ground—the pickup is shorted to ground instead. The overall tone of the instrument is not affected, since the DC resistance of the resistive strip that attenuates the high end is still present. Refer to diagram #5 for an example of this wiring.

Blend controls
These specialty controls combine two audio taper pots that are ganged together and controlled by a single knob shaft. As the shaft is rotated it moves the sweeper in both pots simultaneously. Blend controls typically have a “center detent,” which lets the player know that the pot's in the center of its rotation. At this point both signals are at 100%. Blend pots are the same as “balance” controls found in home or car stereos. They pan the output level from left to right.

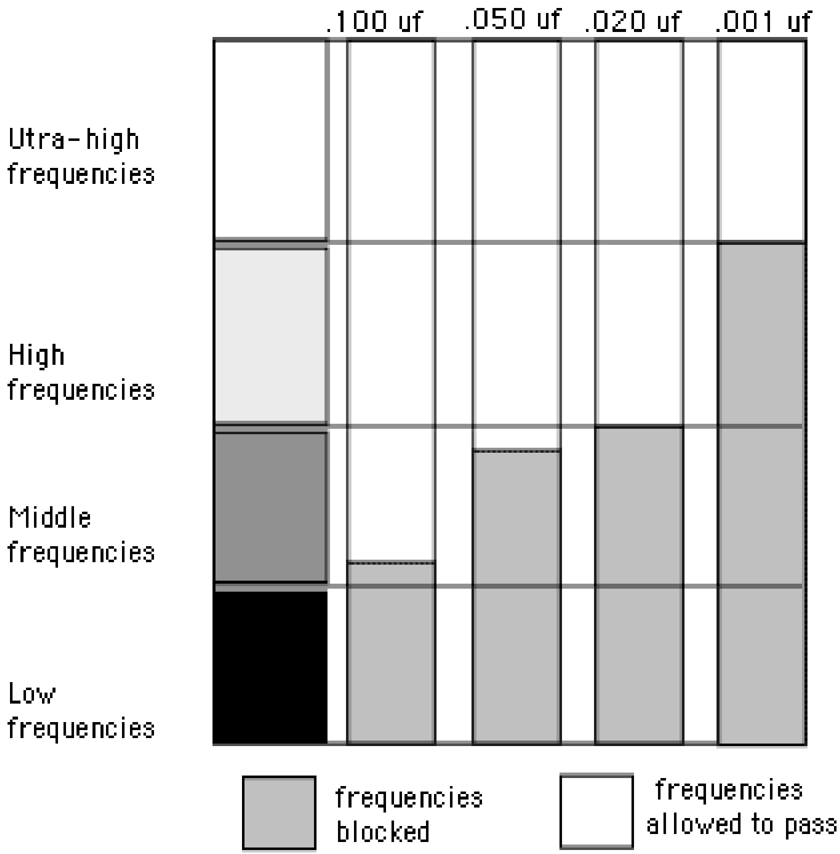
To further understand a blend pot, we need to analyze what is happening as the knob is rotated. Starting at zero, with the pot shaft rotated fully counterclockwise, one channel (we'll call it “A”) or pot is at 100% output and the other channel/pot (“B”) is at 0%. As we rotate the knob clockwise to 2.5, “A” remains at 100% and “B” has gradually increased to roughly 50%. When we reach 5 on the knob (halfway through the blend pot's rotation), both “A” and “B” are at 100%. As we continue to 7.5, “A” has now decreased to 50% and “B” now remains at 100%. When the pot reaches full clockwise rotation—10 on the knob—”A” is now at 0% and “B” is still at 100%. Refer to diagram #6 below for a graphical representation. Since these are audio-taper blend controls, the taper is logarithmic.



What is a capacitor and how does it work?

Capacitors, or "caps," are simple electronic components that are typically used in guitar electronics as filters or barriers for certain frequencies. High frequencies will pass through a cap, while lower frequencies are blocked. The value of the capacitor will determine the frequencies that pass (refer to Diagram #7). Using the filtering properties of a cap, we can affect the tone of the guitar.

Diagram #7

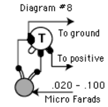


Higher frequencies travel more readily to ground, and a guitar can sound muddy as the volume is rolled off. Many builders overcome this problem by using a ìtreble bypassî capacitor between the input and the output of the potentiometer. The most common treble bypass caps are 680 picofarads (pf) and .001 microfarads (μf). The higher the value of the cap, the more upper frequencies are allowed to travel through it. A tone pot uses the same properties of a cap, but instead of letting the frequencies slip by to the amp, they are sent to ground. Most tone control caps are of a higher value than treble bleed caps, so the overall effect will be more noticeable, with more tonal flexibility.

How is a tone pot is wired?

There are several ways to wire a traditional tone control, yet they all end up working the same way.
Diagram #8 shows the most common method.

Diagram #8



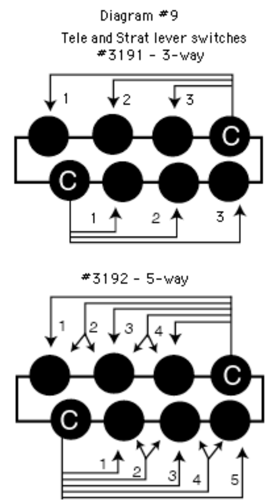
Selector Switches

The pickup switch selects which pickup's output will be sent to the amp. Virtually all pickup selector switches combine pickups in parallel rather than series. Series connections between pickups are possible with a selector switch, but they often require custom wiring.

3-way and 5-way lever switches

When Leo Fender designed the Telecaster®, he used a rather large lever switch that was commonly used in that era. The original 3-position lever switch has two poles. Fender used the same 3-way switch on the Stratocaster® up until around 1977, when the company realized that players had been catching the switch between positions to get two new sounds. Repairman such as Seymour Duncan filed two new stops into these 3-way switches making the first 5-way switches. After 1977, nearly all Fender Strats came with a 5-way toggle.

Except for the two additional stops, electrically and mechanically there is no difference between the 3 and 5-way lever switches. Refer to **Diagram #9** for the lug assignment of these simple but useful switches.



Mini toggle switch basics and push-pull pot basics

Mini toggle switches

The most common mini toggle switches used in guitar wiring are DPDT (double-pole, double throw). Although all of our mini toggles are DPDT, two of them have three positions. Confused? Well, “throws” don't necessarily correspond to positions, so refer to **diagram #11** for what is happening for each position.

A mini toggle switch has a wide variety of functions in guitar wiring. The mini toggle is not designed for any specific reason—you have to tell it what to do. Some typical uses for mini toggle switches include switching phase; series/parallel wiring; coil-cutting; pickup selector, series/split/parallel switch; on/off switching; and more.

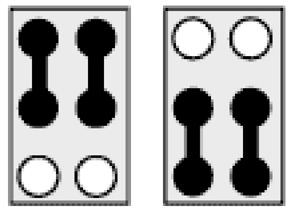
Push-Pull Pots

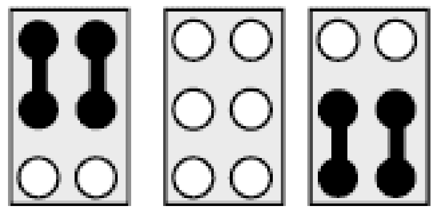
This is yet another powerful tool to the guitar builder or repairman. Two electrically independent components are controlled by a single knob shaft. When the shaft is rotated, the potentiometer (and whatever it's wired to do) is operated. You can also pull up on the knob shaft, which will switch the on/on mini toggle from its “down” position to the “up” position. Remember, the pot and the switch are separate components, so there is no interaction between them unless you wire the push-pull pot to do so. **Diagram #12** helps to demonstrate the lug assignment of the mini toggle in the two positions.

As with the mini toggle switches, there is no specific use for this component.

Diagram #11

Mini Toggle Switches





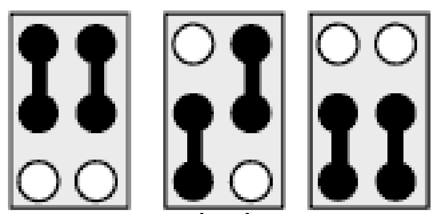
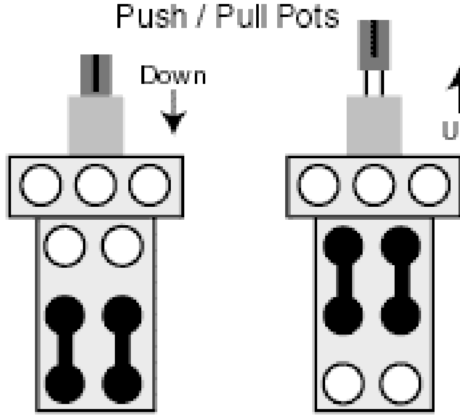


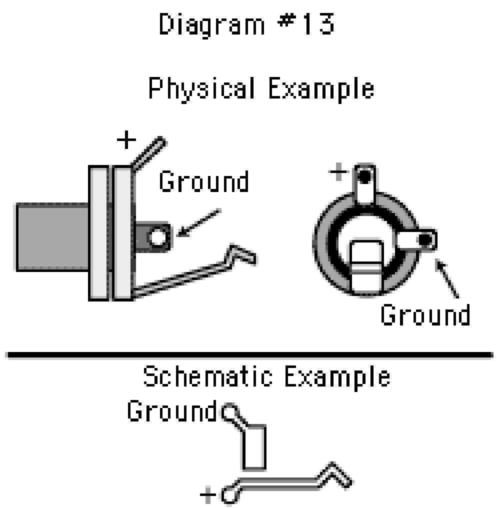
Diagram #12

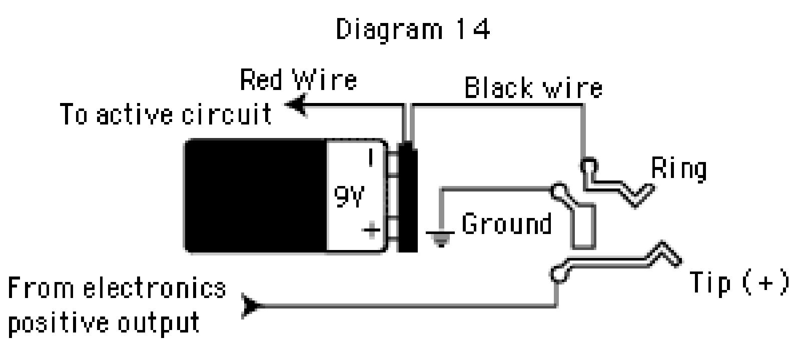
Push / Pull Pots



Output Jacks

The output jack is where it all comes together. The various pickups, pots, switches, and caps eventually direct the signal generated by the pickups to the output jack. Diagram #13 shows a typical mono jack and how it should be connected. Diagram #14 shows how to wire a stereo output jack to turn on an onboard power source (battery) when a 1/4" mono plug is inserted. This works by using the "ring" connector of the stereo jack to complete the ground side of the active onboard circuit when the plug is inserted.





Grounding and Shielding

Shielding eliminates virtually all unwanted interference and hum. In order for shielding to work, must be in contact with ground. There are several ways to apply a ground to a shielding network; when using copper shielding foil, the ground wire can be soldered directly to it. If your volume pot housing is in contact with the foil, a ground jumper to the foil is not necessary. #0029 Shielding paint is also good for shielding control cavities, pickup routs, and drilled holes. The paint is very easy to apply in small tight areas, unlike self-adhesive foils.

To apply ground to a painted cavity, or to a conductive adhesive foil (aluminum or copper) on a Stratocaster® for example, is very simple. Bring the paint or foil over the top of the body in the area that will be under the pickguard, and around the pickguard screw below the bottom tone pot. The foil on the pickguard should surround this screw hole, so that when the pickguard is screwed into place, the grounded foil on the pickguard will come in contact with the cavity shielding. The same technique will work for a Telecaster® control plate/control cavity and a Stratocaster jack plate/jack cavity.

Another method is the use of a solder lug screwed into the cavity's side wall. Make the solder lug out of a scrap of brass and use a small wood screw to affix it. Just solder a wire from the volume pot's casing to this lug for a good ground.

Understanding impedance and impedance matching

Any electrical circuit has an inherent impedance, and electric guitars or electrified instruments are no different. There are exceptions to this rule, but most often the manufacturer of these “different” components has designed other components to change the system to standard high impedance.

Magnetic (High impedance)
High impedance is the standard output for an electric guitar. Most amplifiers and other electric gizmos that players use are designed to work with high impedance magnetic pickups.

Piezos (Ultra high impedance)
Transducers are ultra high impedance devices. Therefore, to attain maximum sonic performance, a preamp/buffer must be used. A buffer takes the ultra high impedance signal and converts it to a standard high impedance signal which most guitar amps, PAs and recording equipment can handle.

Many players use a “stomp box” effects unit between the guitar and the amp or PA, instead of an onboard or external preamp/buffer. Since many floor effects can accept an ultra high input impedance and deliver a standard high impedance output, they can be used as a buffer. Graphic or parametric equalizers are a logical choice, as they offer frequency control and buffering.

Magnetic (Low impedance)
The most common low impedance magnetic pickups are the “active” pickups sold by EMG and other specialized manufacturers. They differ from high impedance designs in that they typically use fewer turns of a lower gauge (thicker) magnet wire. These coils have a low DC resistance, which translates into a very low output, but very wide frequency response.

To compensate for the extremely low output and to buffer the signal to high impedance, these manufacturers build small preamps (often sealed inside the case of the pickup) that are powered by an onboard 9-volt battery. This is where the term “active” comes from. These small preamps are very clean, and boost the output of the pickup, often to very high levels. Typically, high impedance pickups never break the 1-volt output range, while some low impedance designs exceed 2 volts. Some of these pickups are designed to be VERY hot, which will drive the preamp section of a guitar amp very hard. This is desirable for high-gain rock-n-roll.

A few makers (Alembic is the most notable) retain the low impedance signal out of the guitar and send it to specially designed amps, or often directly into PA boards. PAs are designed to accept low impedance inputs, as most good microphones—for improved frequency response—are low impedance.

Wiring Glossary

60-cycle hum Interference and noise that is emitted by most electric devices. The humbucking pickup was designed to eliminate this RF interference.

Alnico	An acronym for an expensive and powerful permanent-magnet alloy containing iron, Aluminum, Nickel, and one or more of the elements Cobalt, copper, and titanium (Al-Ni-Co). There are several different formulations of Alnico and they are designated using roman numerals. The most common are Alnico II (two) and Alnico V (five) for guitar and bass pickups. Alnico is often preferred over other permanent-magnet materials (such as ceramic) for its tonality and response.
Antenna	A usually metallic device (as a rod or wire) for radiating or receiving radio waves. A pickup coil is a very long wire antenna. One complete wrap of a traditional single-coil averages around 4-1/2" long. Therefore, a pickup with an average 6,000 turns has 3000 feet of wire—over half a mile!
Alternating Current (AC)	An electric current that reverses its direction at regularly recurring intervals or cycles.
Amplifier	Boosts an electrical signal from the pickups to a much greater signal that can power the amplifiers speakers.
Attenuate	To reduce or cut.
Backplate	A plastic cover that conceals the tremolos block, springs, and claw, or covers the electronics cavity.
Bobbin	The part of the pickup that the coil-wire is wrapped around.
Cable	Often referred to as a cord or guitar cable, it carries the electrical signal produced by the pickups to the amplifier.
Capacitor	An electrical component, which has many uses (storing electricity, acting as a filter and more). Typically, guitar wiring uses a cap as a filter for certain frequencies, in conjunction with a pot to affect the tone of the guitar.
Capacitor (2)	A device giving capacitance and usually consisting of conducting plates or foils separated by thin layers of dielectric (as air or mica) with the plates on opposite sides of the dielectric layers oppositely charged by a source of voltage and the electrical energy of the charged system stored in the polarized dielectric
Ceramic-Magnet	A powerful permanent magnet material, which is made by combining a nonmetallic mineral (such as clay) with other materials, and by firing them at a high temperature. This material can then be magnetically charged using a capacitance discharge devise, or another magnet.
Coil	The bobbin, magnet, and coil of magnet-wire assembly.

Coil-wire	See magnet-wire.
Conductive	A material with the ability to transmit or convey energy (electrical, magnetic, heat, etc.). Some materials are better than others for transmitting, while act as resistors to the transmission of energy.
Cycle	An interval of time during which a sequence of a recurring succession of events (i.e. Alternating Currents reversal in direction) is completed. Standard US wall voltage is 60-cycle AC. This translates into 60 "reversals" per second.
Direct Current (DC)	An electric current flowing in one direction only and substantially constant in value.
Electrical Current	A flow of electric charge; also the rate of such flow. See alternating current and direct current.
Electromagnet	A core of magnetic material surrounded by a coil of wire through which an electric current is passed to magnetize the core.
Electromotive Force	a) Something that moves or tends to move electricity. b) The potential difference derived from an electrical source per unit quantity of electricity passing through the source (as a cell or generator).
Farad	The unit of measurement used for capacitors. Caps used in guitar wiring are typically measured in microfarads (a unit of capacitance equal to one millionth of a farad) and picofarads (one trillionth of a farad).
Farad (2)	The unit of capacitance equal to the capacitance of a capacitor between whose plates there appears a potential of one volt when it is charged by one coulomb of electricity. Etymology: Michael Faraday, 1873
Flatwork	The two stamped pieces of vulcanized-fiber material traditional Fender-style single-coil pickups used in the construction of the pickup bobbin. The six magnets were pressed into two pieces of flatwork (one for the top of the coil and the other for the bottom).
Ferrous	Of, relating to, or containing iron.
Finish	The end of a coil.
Gauge	Referring to wire. The higher the gauge number of the wire, the thinner its diameter. The thinner the diameter (the higher the gauge), the higher its DC resistance per linear foot.

NOTE:	There are tonal differences between two coils with the same number of turns of two different gauges. The thinner-wire pickup will have a higher DC resistance, and therefore a different response than a pickup utilizing a thicker gauge coil-wire. If a pickup is wound to a specific DC resistance, a higher gauge (thinner) wire will achieve that resistance quicker than a thicker gauge wire.
Gauss	The unit of measurement for a magnetic field and its strength.
Generator	A machine by which mechanical energy is changed into electrical energy.
Ground	The base or zero reference point that electrical potential or voltage is measured. Guitar circuits have a common ground and are connected to earth ground through the amplifier.
Hand-Wound	Using a simple winding machine, the operator guides the coil-wire onto the spinning bobbin by hand. This gives the operator complete control of the tension of the winding, the traverse, and the concentration of the windings. This is how many single-coil pickups are wound, which allows the operator to have some control over the pickup's output and tone.
Hollow Body Electric	Guitars that can be heard un-amplified as well as amplified because of their soundboard. They produce softer, warmer tones preferred by jazz and blues musicians.
Humbucker	Two coils of opposite magnetic polarity and opposite electrical phase, which effectively cancel 60-cycle hum. Humbuckers typically have a warm tone with an increased upper-midrange, and attenuated lows and highs. Seth Lover of the Gibson Guitar Company designed the humbucker in 1956. Since the two coils of a humbucker work with one another to cancel hum, then both coils must be as close to identical as possible. This is why humbuckers are almost always machine-wound. If the coils had varying inner-coil tensions, inconsistent numbers of wraps, and an uneven traverse (all indicative of a hand-wound pickup), then they would not sound smooth and they wouldn't effectively cancel hum.
Inductance	a) A property of an electric circuit by which an electromotive force is induced in it by a variation of current either in the circuit itself or in a neighboring circuit. b) The measure of this property that is equal to the ratio of the induced electromotive force to the rate of change of the inducing current.
Impedance	The measurement of the overall resistance of an electrical circuit.
Impedance (2)	The apparent opposition in an electrical circuit to the flow of an alternating current that is analogous to the actual electrical resistance to a direct current and that is the ratio of effective electromotive force to the effective current.

In-Phase The linking of two signals so they are working identically, in a synchronized or correlated manner. The opposite of out-of-phase.

Intonation The process of adjusting a string's length (using the individual saddles of the bridge) so that each string plays in tune at every fret relative to all of the other strings.

Jack Plate A mounting apparatus for the output jack.

Machine-wound Pickup coils that have been wound using a completely autonomous winding machine. Most humbucking and many single-coil pickups are machine-wound rather than hand-wound.

Magnet A ferrous (containing iron) material or certain other material which can be magnetically charged and therefore will attract other ferrous or similar materials. Pickups are often manufactured first, then the magnets are charged. Magnetism is measured in Gauss.

There are two common methods for charging the magnets of a pickup. One method is to simply introduce the pickup to the field of another, larger magnet and let it charge the magnet(s) of the pickup. The orientation, proximity, and exposure time of the pickup relative to the large magnet will determine the polarity and intensity of the pickup’s magnet(s). Therefore, this method can give varied results. The other, more precise method utilizes a capacitor discharged into a coil of wire (similar to a large solenoid). The pickup is placed within the coil of wire, the capacitor is charged with a preset amount of voltage and current, and then the capacitor is allowed to discharge into the coil. The coil will become a very stable, but short-lived magnetic field surrounding the pickup. This short burst of magnetism can be repeated as many times as necessary to produce a consistent product.

Magnetic Polarity see polarity.

Magnet-Wire Very thin (generally 43-42 gauge, .0022-.0025"; human hair is .0025"), flexible copper wire which is coated with a non-conductive “insulation”—usually a thin plastic finish such as lacquer or polyurethane.

Millivolt One thousandth of a volt.

Ohm The unit of measurement for resistance. The higher the value, the greater the resistance.

Ohm (2) The practical meter-kilogram-second unit of electric resistance equal to the resistance of a circuit in which a potential difference of one volt produces a current of one ampere.

Out-of-Phase The combination of two signals or waves so they are unsynchronized, or not in correlation—they are 180-degrees out-of-synch. The opposite of in-phase.

Output The power or energy produced or delivered by a machine or system, in our case, the pickup(s). It is virtually impossible to measure a pickup's output (not the DC Resistance, but its actual output voltage) since the forces that induce a current into a pickup's coil(s) vary considerably. This is due to the fact that string-gauges, the string's proximity to the pickup and polepieces, the vibrating length of the string, and the force at which the string is plucked can vary considerably.

DiMarzio is the only company I'm aware of that even advertises their pickup's voltage output. They went to great lengths to ensure that the variables listed were maintained at a constant so they could quantitatively compare their pickups and give a specific DC Volt output for each model.

Output Jack This is a receptacle that accepts the cable, which is then connected to the guitar amplifier.

Parallel When two or more electrical components are combined so that their inputs are connected and their outputs are connected.

Parallel (2) An arrangement of electrical devices in a circuit in which the same potential difference is applied to two or more resistance's with each resistance being on a different branch of the circuit—compare to series.

Phase The relationship of positive and negative waveforms. See in-phase and out-of-phase.

Pickguard Generally made of some type of plastic, it is used to suspend the pickups, pots and switch. The pickguard is held in place by pickguard screws.

Pickup The component of an electric guitar that transmits the vibration of the strings into an electrical signal. The pickup has three primary parts: 1) magnet(s); 2) copper wire; 3) bobbin.

Permanent-Magnet Any material that will retain a magnetic charge much longer than a simple ferrous alloy. The original permanent magnet material was the mineral lodestone (Magnetite), which was known to the ancient Greeks, Romans, and Chinese. They found that when a piece of iron is stroked with lodestone, the iron acquires the ability to attract other pieces of iron.

Polarity The particular state, either positive or negative, with reference to the two poles or to electrification.

Polarity (2) The particular state, either north or south, with reference to the two poles or to a magnetic charge or field.

Pole Referring to a switch; a distinct circuit that will not interact in any way with any other pole.

Polepiece Part of a pickup which senses string vibration. Depending upon the design of the pickup, the polepieces may not be actual magnets, but they must be magnetically conductive.

Potentiometer Often referred to as a "pot," it's an electrical device consisting of a resistive strip and a variable sweeper. The resistance strip is equal to the pot's value (250K, 500K, 1Meg, etc.) and its ends are the two outer lugs (1 and 3). The middle lug (2) is connected to the "sweeper" which travels along the resistance strip as the pot shaft is rotated. The location of the sweeper determines the amount of resistance between lugs 2 and 3, and 2 and 1. The pots used in guitar electronics are generally "audio taper." This means that the resistive strip has a special logarithmic taper to compensate for how the human ear perceives changes in volume. This allows the musician to vary the volume and/or tone of an electric guitar in a smooth, gradual manner.

Preamp An electrical device which is designed to boost and/or buffer a signal's strength and/or impedance.

Resistance The restriction or impedance of electrical flow.

Resistance (2) The opposition offered by a body or substance to the passage through it of a steady electric current.

Resistor An electrical component designed to apply a predetermined amount of resistance to an electrical circuit.

Resistor (2) A device that has electrical resistance and that is used in an electric circuit for protection, operation, or current control.

RF Interference The ever present Radio Frequencies that bounce around the world. It is the source of 60-cycle hum and is emitted by virtually any electrical device. The humbucking pickup is designed to eliminate or cancel-out RF Interference.

Scatter Winding See hand-wound.

Selector Switch Determines which pickup or pickups are connected to the amp.

Series When two or more electrical components are connected so that the output of one component feeds into the input of the next component.

Series (2) An arrangement of the parts of or elements in an electric circuit whereby the whole current passes through each part or element without branching—compare parallel.

Seth Lover An incredible “renaissance-man” in the history of Gibson's electric guitars, and the inventor of the humbucking pickup design.

Short Circuit (a.k.a. short) A connection of comparatively low resistance accidentally or intentionally made between points on a circuit between which the resistance is normally much greater.

Single-Coil A pickup comprised of a single bobbin. Most single-coil designs use polepieces that are made of a magnetic material (typically Alnico II or Alnico V) that are pressed into the flatwork. Single-coil pickups typically have a wider frequency response when compared to humbuckers, and they also have a tighter low-end response as well as more high-end. Due to a single-coils high-end or “bright” sound, manufacturers will often use 250K volume controls to attenuate some of the high-end frequencies. This gives them a warmer, smoother response.

Most tone aficionados prefer hand-wound single-coil pickups to machine-wound varieties. There are many reasons for this, many of which are subjective. Some of the best sounding single-coil pickups were made in the 50's and 60's at the Fender factory. Several elderly women wound thousands of pickups by hand feeding the wire onto the bobbins. These pickups, which don't look nearly as neat and clean as a machine-wound pickup (the coils were lop-sided, uneven, and often warped) sound and respond better than any other single-coils produced. Leo preferred elderly females for the pickup winding, since they had experience in winding sewing string and yarn, and seemed to have the right “touch.”

Solidbody Electric A guitar body made of a solid piece or pieces of wood without any soundboard.

Soundboard The top or face of an acoustic or hollow-bodied guitar which vibrates along with the strings and projects the sound of the guitar.

Start The beginning of a coil.

Throw Referring to a switch; the number of distinct stopping points or terminals of a given pole of a switch.

Tone Control A potentiometer and capacitor wired to control certain frequencies of the pickup's output.

Traverse A zigzag course of consecutive lateral movements, which will disperse the windings onto the bobbin.

Variable Resistor See Potentiometer

Volt The practical meter-kilogram-second unit of electrical potential difference and electromotive force equal to the difference of potential between two points in a conducting wire carrying a constant current of one ampere when the power dissipated between these two points is equal to one watt and equivalent to the potential difference across a resistance of one ohm when one ampere is flowing through it.

Volume Control A potentiometer wired to determine the volume, output, or loudness of the instrument, or a portion of an instrument's electronics (say one pickup relative to another). A “master” determines the level of the signal sent on to the amp.

Wax Potting The process of immersing a pickup's coil(s) into hot wax. This allows the wax to penetrate into the windings and components of the pickup so that they will not vibrate, thus eliminating microphonic feedback.

Winding Machines A mechanical means to assist in the winding of the coil-wire around a bobbin to make a pickup coil. The machines are often very simple; with an arbor for the bobbin, a motor to drive the arbor, and a variable speed control for the motor. More advanced winding machines have methods for guiding the coil-wire onto the bobbin, controlling the traverse (number of wraps per layer and the wires spacing), winding counters, tensioning for the coil-wire, and more. If you wish to make your own pickups, a simple winding machine could be made from an old sewing machine motor and controller, and a simple arbor made of wood.

Windings The wraps of copper wire around the bobbin of a pickup. Coils generally have anywhere from 6,000 to 8,500 turns of wire. The number of turns is often used as a rough indicator of a pickups potential output and tone. The higher the number, the higher the output, but not always. As the number of windings increase, the pickup will also lose some clarity, and high and low-end response. Generally, high-output pickups have increased upper midrange response, but high and low frequencies are compromised.

Typical single-coils are wound from 4 - 6.5K ohms, while typical humbuckers wired in series (this means that each coil of the humbucker is half the DC resistance reading) measure 7 - 9K Ohms. The gauge of wire and the number of windings will determine the actual size of the pickup coil. Smaller wire (43-gauge for example) will give a greater DC resistance with less windings, compared to larger (42-gauge) wire.