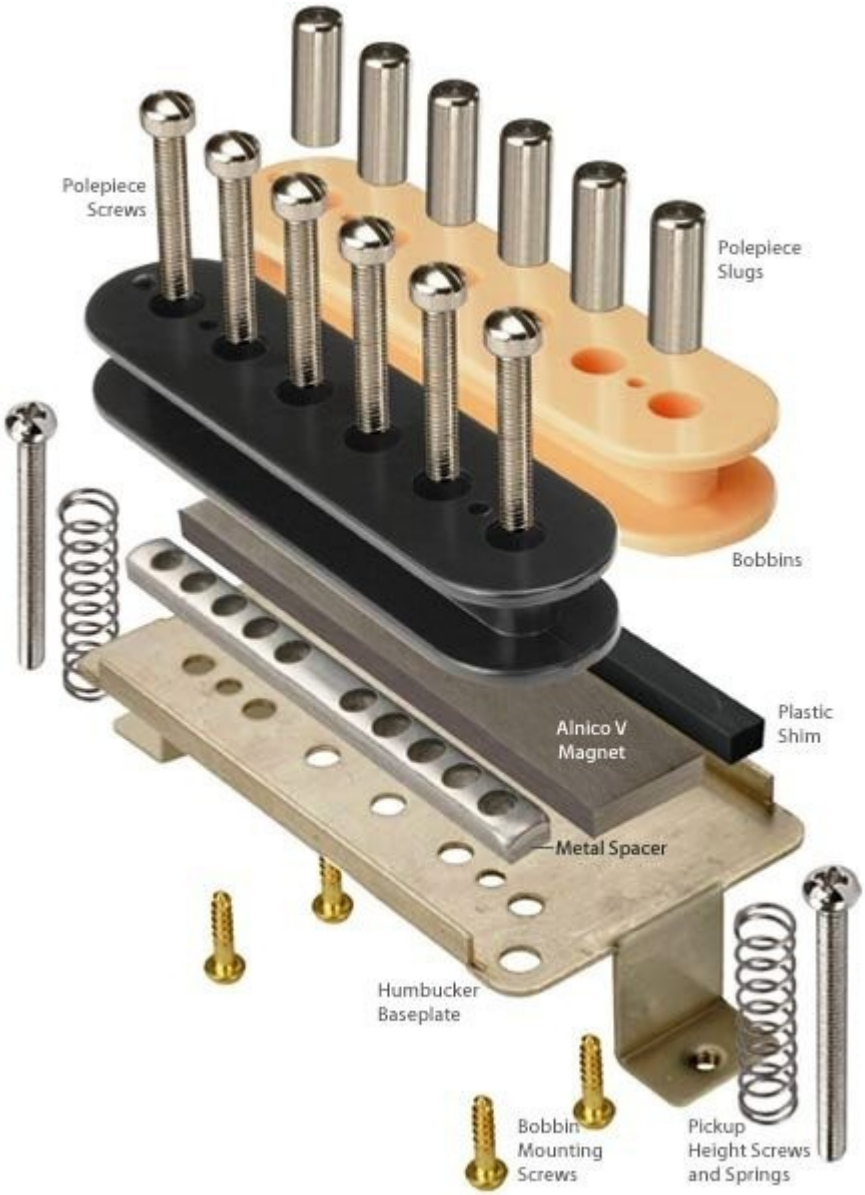
Guitar Pickup Basics

ALNICO MAGNET TYPES



Magnetic flux is measured in Gauss - this is an indication of how strong a magnet is capable of being. Magnetic field intensity is measured in Oersteds. Technically speaking, the strength of a magnet is best measured as an approximate combined product of the Gauss and Oersteds. This is somewhat analogous to how electrical power in Watts is the product of Volts and Amps (Volts x mA = Watts). For example, 40 mA at 250 volts (40 x . 250) produces 10 watts per tube, and the same 40 mA at 500 volts (40 x . 500) produces 20 watts. So, when considering magnetic strength, ultimately, both Gauss and Oersteds are factors. That said, I'll keep the scope of this article to the commonly used measurement of Gauss, as such understanding provides sufficient insight into magnetic properties relating to guitar pickups.

Alnico stands for Aluminum (Al), Nickel (Ni) and Cobalt (Co). Other than Iron (which comprises about 50% of all Alnico magnets), these are the main metals used in Alnico magnets. All grades except Alnico IV have a bit of Copper (Cu) in them too. Alnico III contains no Cobalt. Alnico IV possesses the weakest gauss of all commonly used Alnico magnets, and Alnico V has the strongest gauss. More specifically, the order of Alnico magnet gauss level from weakest to strongest is: Alnico IV -> Alnico III -> Alnico II -> Alnico V. This said, though rare, one can still have an Alnico V magnet that's weaker than an Alnico II, III or or even IV magnet, because magnets are not always fully charged. Yet, Alnico V has the capacity to hold a stronger magnetic charge than Alnico II, III or IV.

Following is data regarding gauss meter readings on approx 80 Alnico magnets. The magnet types checked were both polished and rough cast:

Various new Alnico II pickup magnets measured at gauss levels ranging from 22 to a high of 35, with most in the 25 to 30 gauss range. New Alnico V magnets ranged from 22 to a high of 36, with most in the 30 to 35 gauss range. Alnico V magnets tested from older Gibson "T-top" pickups (30+ years old) all measured in the 25 to 30 gauss range, with most reading 25 to 27 gauss. So, interestingly, older "T-top" pickups show moderate gauss level readings for Alnico V. Vintage (late '50s thru early '70s) Gibson pickup magnet gauss readings, on both Alnico II and V magnets, consistently averaged 25 to 30 gauss. And, all the magnets read stronger towards one end of the magnet, which could possibly have tonal implication on magnet orientation in the pickup.

Alloy	Al %	Ni %	Co %	Cu %	Gauss
Alnico II	10%	19%	13%	3%	7,500
Alnico III	12%	25%	-	3%	7,000
Alnico IV	12%	28%	5%	-	5,600
Alnico V	8%	14%	24%	3%	128,000

The type and strength of magnet in a pickup can have about as much impact on tone as winding resistance. All other factors being equal, a weaker magnet effects tone by lowering both output and resonant peak (perceived as a less prominent high-midrange and treble response). While, contrarily, a stronger magnet will function to increase output and raise the resonant peak. For example, a midrange-prominent humbucker reading in the higher ranges (say 9k+) might exhibit an output approaching that of a strong single-coil pickup, if it features a relatively weak magnet. And, conversely, a bright and airy sounding humbucker pickup reading in the lower ranges (say around 7.5k) can produce output akin to a typical "hotter" wound pickup, as is sometimes experienced with Alnico V magnet pickups like the"T-top", for instance.

Additionally, long magnets (PAF-style) are slightly punchier sounding and have better tonal definition than shorter magnets- short magnets can sometimes produce a slightly "smeared" sound. Though magnet type can compensate for this, as Alnico V's additional output, punch and brightness balanced out the shorter magnet size Gibson used beginning 1961. Lastly, its worth mentioning how the stud-side pickup coil actually has slightly more output than the adjustable side on a traditional humbucker. There is a direct connection to the magnet inside the pickup on the stud side, while the adjustable pole extends out the bottom of the pickup. And, there is a slight loss of magnetic field and energy out the bottom of the pickup.

Bobbins, Wire and Winding

A pickup's treble response is related to the magnet strength interacting with the windings. Think of it as a bell curve. The more winds, the brighter the pickup gets, but only up to a certain point. After that point more winds take away treble. The stronger the magnet the more winds you can add before the treble starts to drop off. Yet, all other factors being equal, inductance increases and treble response decreases, the higher the number of winds.

Resistance is only one indication of a pickup's overall output -it tells a lot about the actal character of a pickup only when one consider the magnet that is used with it. And, bobbin types are ke - skinny and tall coils produce a clearer sound than short and wide coils, all other factors being equal. Also, you can have a pickup with a higher resistance that has less output if the wire gauge is thicker or magnet gauss is lower than the pickup being compared. Or, you can have one pickup that is lower resistance with higher output if the wire is smaller diameter. Additionally, with tight wound coils the wire stretches a bit, which will give a higher resistance reading, because of the additional wire length. Loose winding generates a brighter tone, because with two identically sized coils wound from the same wire, the looser coil will have fewer winds than the tight coil.

Resistance is actually measuring the length of wire used in a coil and doesn't necessarily indicate how many turns are used, as wire thickness and bobbin sizes vary. If a pickup is longer or larger, it will have the same resistance with less output due to the lower turn count. Turn count is really what determines output, but seeing how there is no way to count turns on an already wound pickup people use resistance for output comparison.

Fewer winds will have an audible effect, because the pickup will have less inductance, which affects the frequency response - making the pickup brighter. The pickup inductance interacts with the guitar volume/tone controls, guitar cable capacitance, and amplifier input load to create an EQ network. More inductance causes more highs to be lost in this EQ circuit. This also means that resistance 'specs' are misleading, because the turns count is what really makes the pickup sound they way it does. Inductance itself is related to the square of the turn count, so a small error in turns becomes a large error in inductance. By winding to a resistance value, you can't get the turns count right because you don't know what tension other pickup makers are using. But, by winding to a specific turn count or inductance value,

you stand a much better chance of winding a successful pickup.

A traditional PAF pickup uses 42 gauge plain enamel insulation wire. Then there are other types of insulation like polyurethane, which would mean the coil wire might have a different overall diameter, so not all 42 gauge wire is created equal. There are also lighter wires, such as 43 or 44 gauges. In general, thinner wire will create a more high-frequency loss than thicker wire, all other factors being equal. Interestingly, in this same coil, polyurethane and heavy-build wire usually wind to same resistance and have the same inductance, and plain enamel is noticeably higher in resistance and inductance.

If you wind two identical coils, same resistance, but one with heavy-build insulation, the heavy build insulation coil will be noticeably brighter. It's because there's more capacitance going on since the actual metal in the wire has more gap between wires because it's filled with heavier insulation. So, if that's true then theoretically a looser coil would have the same effect. Moreover, polyurethane wire facilitates a punchier tone, while plain-enamel has a more vintage tonal character.

So, if other wire factors differ, you'll have different behaviors. For example, if the coating has a different dielectric constant or thickness, the overall parasitic capacitance will change together with inductance, which shifts the resonant peak consequently. With loose windings or wire of same AWG but thicker insulation, you'll have a lower inductance and parasitic capacitance, so even if the number of windings stays the same, the resonant peak will be higher and the output lower.

Rating Pickups with DC Resistance

DC resistance is NOT a power rating, rather its the resistance of the wire in a pickup's coil at zero hertz, something that only occurs when a guitar isn't played. DC resistance specs are inadequate as sole power and tone indicators of an AC device like a pickup. Small fluctuating AC (not DC) voltages from pickups are what control outpout from an amp or plate currents of a tube. The large current flowing through the plate fluctuates with the same frequency as the small guitar pickup voltage, and the tones we love come through. An amplifier makes the small AC signal coming from your guitar pickups big enough to move a speaker cone.

If we do use DC resistance as a parameter for indicating tonal response, for one, we disregard the fact that this resistance rating is frequency dependant. Tonal output varies across the frequency spectrum. Additionally, the pure output rating of a pickup is more accurately indicated in millivolts. Millivolts could be a helpful parameter in indicating pickup output and tone if manufacturers agreed on a standard measuring method that provides such data measured at various frequencies over a wide frequency range.

Inductance is another important parameter to consider in the sonic evaluation of a pickup. Put in simplest terms, as a general rule the higher the inductance, the lower the treble response and the higher the output and midrange emphasis will be. For examples, a traditional Strat pickup has an inductance around 2.3 henry, while a Gibson PAF has an inductance around 4.4 henry, and some of the so-called "distortion" pickups have an inductance above 8.0 henry. With these comparisons, you get a basic idea of this quality.

So, several important factors can to be considered to more accurately speculate the tone and output of a pickup - tone and output depend mainly on the relation between magnetic strength, wiring resistance and the resulting inductance of a pickup. And, don't forget the relation between the inductance of the pickup and the capacitance of guitar cables and effects. Guitar cable capacitance especially impacts frequency response and output.

Pickup Cover Effects

Pickup cover types are another important aspect of tonal influence. Contrary to popular conception, it's not so much whether you use covered or uncovered pickups that makes the most tonal difference. Nor, does the type of plating on a given cover make any considerable difference. Rather, what is most crucial to a pickup's tone is two things: the exact metal or alloy a pickup cover is made of and the cover base thickness.

Solid-brass covers are usually the worst in terms of transparency and loss of high-end. Solid nickel-silver is the most transparent cover alloy, and it retains highs best. Yet, covers that are too thick (even nickel-silver) can impact tone as negatively as brass covers even. Specific covers to avoid are brass, too thick nickel-silver and cheap alloys in general, as varying compositions of metal alloy effects tone differently.

So, a quality nickel-silver cover that isn't too thick will not exhibit tonal degradation compared to an uncovered pickup. Any competent pickup maker will know if the covers on their humbuckers are quality nickel-silver of moderate thickness, so be sure to ask when purchasing aftermarket pickups.

Other Factors Influencing Pickup Tone

The electric guitar is still fundamentally an acoustic instrument. And, any given pickup responds very differently to each and every guitar model. The wood (or other materials) of a guitar absorbs some frequencies and resonates others. And, a pickup only picks up the frequencies and levels that a string is generating. So, for instance, if you have a guitar that absorbs frequencies most readily between 200 and 500 Hz, you will likely have thinner sounding treble strings, than if the guitar absorbed higher range frequencies. If your guitar resonated well between the previously mentioned frequencies, it would facilitate beefier treble string response. Additionally, guitars that are more resonant allow you to use a lower output, brighter pickup and still get the same volume.

Last but not least, it is every player's unique articulation and musicality that ultimately impacts a listener's perception of tone. As intangible as this aspect is, every players unique touch is a crucial factor influencing tonal perception. Not convinced? I ask you this then: How many have heard mediocre players playing through the finest "holy grail" gear, whether live or on the internet, only to be left unmoved by the tone. And, conversely, how many have listened to recordings of brilliant players playing through something like a $50 battery-powered Pignose amp (as used on Derek and the Dominos' Layla album, for instance), only to be left amazed at the tone achieved? I've experienced this phenomenon countless times - it's the magic alchemy tone and musicianship.

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