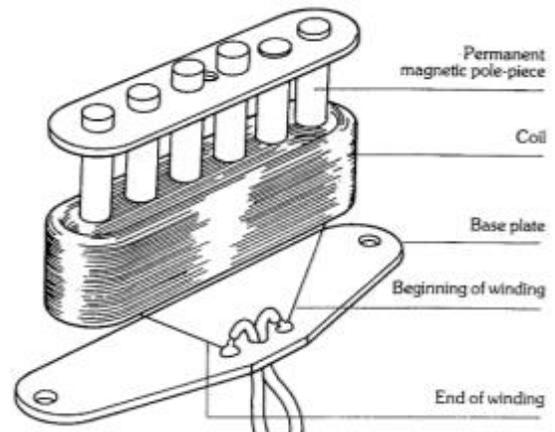


# The Magnetic Guitar Pickup

The electric guitar has been a vital element of music creation starting in the early 1950's. Since its creation in the 1930's, the electric guitar has evolved into an instrument that is capable of creating a multitude of sounds found in numerous genres of music. The driving element of an electric guitar that allows the sound of its strings to be heard is the pickup. Although capable of producing many different sounds, the basic principle of the pickup is the same for most electric guitars available today.

## Construction

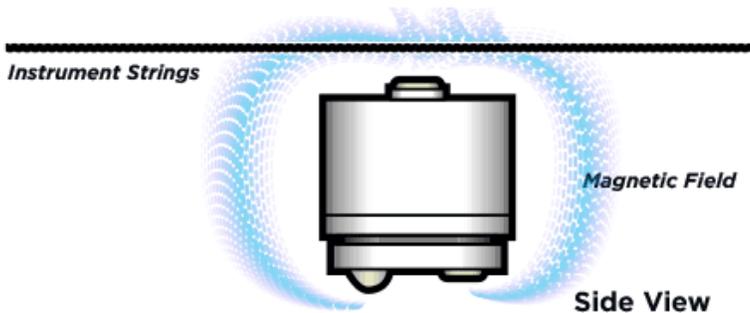
A magnetic pickup is constructed of several permanent magnets that are wrapped in a coil consisting of several thousand turns of copper wire. A visual depiction of this can be seen in *Figure 1*.<sup>1</sup> The permanent magnetic rods typically contain cores of ferrite or alnico. Alnico magnets are made from an alloy of Aluminum, Nickel, and Cobalt while ferrite magnets are usually constructed from iron oxides.



**Figure 1: Pickup Configuration**

## Function

The permanent magnetic rods create a magnetic field that surrounds the pickup as depicted in *Figure 2*.<sup>2</sup> As an electric guitar is played, the motion of its steel strings disrupts the magnetic field produced by the magnets. This disruption causes a change in the magnetic flux that induces a current in the coil that is wrapped around the magnetic rods. The induced current produces a measurable voltage difference between the two ends of the coil that typically ranges between 100 mV and 1 V. By attaching wires to both ends of the coil, as depicted in *Figure 1*, this voltage signal is fed through the rest of the electric guitar's circuitry.



**Figure 2: Pickup Magnetic Field**

## Microphonic Noise

Although the wire coil in a pickup is tightly wound around the magnetic rods, the coil can vibrate at high volumes causing undesired microphonic noise. In order to eliminate this effect, coil pickups are typically dipped in hot wax. The hot wax fills in all of the small gaps between coil windings and hardens, forcing the coil to remain fixed in place. By fixing the coil in place, the microphonic noise is essentially eliminated.

<sup>1</sup> Image source: <http://www.proaudioland.com/news/pickup-wax-potting-explained/>

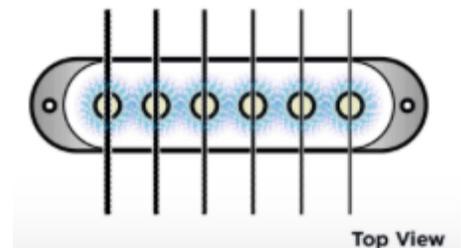
<sup>2</sup> Image source: <http://www.seymourduncan.com/support-pickups-101/getting-started>

## Types of Pickups

Early pickup designs used a single bar magnet that spanned across all the instrument's strings. Newer pickup designs use a separate magnetic rod for each string, as discussed above. Over the years, there have been several different configurations, variations and adaptations that have been developed out of curiosity and experimentation. Different pickup designs can produce different sounds. The pickups most commonly found in guitars today are Single-coil and Double-coil pickups.

### Single-coil Pickups

Single-coil pickups are constructed exactly how their name suggests, they employ a single coil of copper wire surrounding one or several magnetic rods. A top view depiction can be viewed in *Figure 3*<sup>3</sup>. There are several different variations available today, some popular examples include the fender single-coil, the Gibson P-90, and the Danelectro Lipstick.

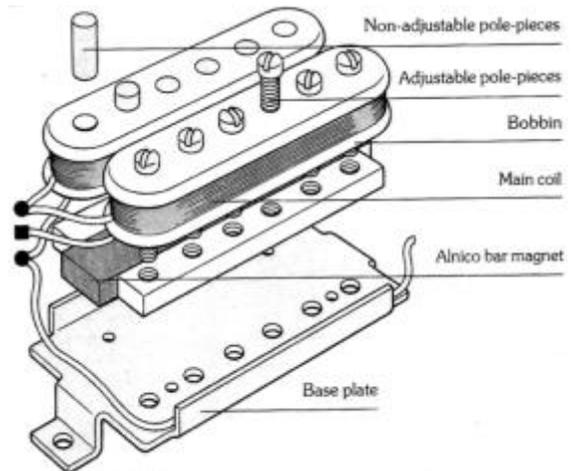


**Figure 3: Single-coil Pickup**

A common issue with single-coil pickups is noise. A major cause of this noise is “hum” caused by magnetic fields created by currents, typically 50 or 60 Hz, in electrical equipment such as power cables and power transformers. The magnetic flux changes caused by these currents is picked up by the coil windings in the pickup. This causes an undesired hum in addition to the desired sound from the guitars strings.

### Double-coil Pickups - “Humbuckers”

The Double-coil pickup, commonly referred to as the “Humbucker”, was developed as a solution to the noise issue common with Single-coil pickups described above. As depicted in *Figure 4*<sup>4</sup>, the Humbucker pickup is constructed of two coils of copper wire. Each coil is wound in the opposite direction as the other, placing them out of phase with each other. In addition to reversing the coil windings, the magnetic rods surrounded by each coil have the opposite polarity positioned upward. This reversal places the magnets out of phase with one another. Each coil in the Humbucker picks up noise in the same manner as the Single-coil, however because the coil windings are reversed the noise is canceled out when the signal from both coils is combined. While the undesired noise is canceled, the signal from the guitar strings is doubled due to the reversed polarity of the magnetic rods. The reversal of the magnetic poles and the coil windings creates a phase difference. The phase difference in the magnets in combination with the phase difference in the coils places the string signal from each coil in phase with the one another when the two coils are wired in series.



**Figure 4: Double-coil Pickup**

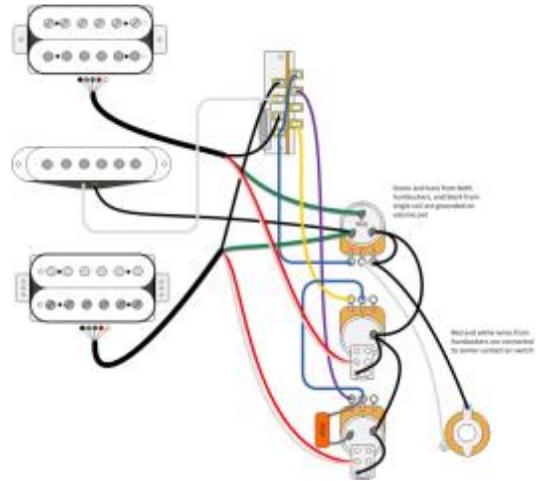
<sup>3</sup> Image source: <http://www.seymourduncan.com/support-pickups-101/getting-started>

<sup>4</sup> Image source: <http://48chicagoblues.com/EMG%20H1A/EMG%20details.htm>

## Pickup Combinations

Guitars today contain both Single-coil and Double-coil pickups as well as combinations of the two. While Single-coil pickups are more susceptible to noise, they tend to produce a brighter and crisper sound with greater note definition between strings. Humbuckers produce a louder, darker, and heavier sound that is very desirable to some guitarists, while others prefer the sound of Single-coils. Pickup choice, many times, is heavily based on the style of music the guitarist is playing and the “sound” they are after.

Many guitars employ either Single-coil or Double-coil pickups, however there is a significant number that feature both. Fender guitars typically contain Single-coils and Gibson guitars traditionally contain Humbuckers, but both companies have strayed from this in the past. By using both Single-coil and Humbucker pickups in a guitar, it allows the guitar to produce a wide variety of sounds. The circuit wiring of guitars allows guitarists to select between the guitar’s pickups using a toggle switch. Guitarists can choose between pickups individually or a combination of multiple at once. *Figure 5*<sup>5</sup> is a wiring diagram for a guitar using two humbucker pickups along with a Single-coil. an example of a popular guitar that employs a combination of both pickup types is the Fender HSS Stratocaster depicted in *Figure 6*<sup>6</sup>. The Fender Stratocaster traditionally contains three Single-coil pickups, however by adding a humbucker into the mix it allows the guitar to produce a sound that resembles that of a Gibson Les Paul, depicted in *Figure 7*<sup>7</sup>, which employs two Humbuckers. The sound of a guitar depends on many factors, body construction and material for example, but one of the biggest contributors is the pickups.



*Figure 5: HSH Pickup Wiring*



*Figure 6: Fender HSS Stratocaster*



*Figure 7: Gibson Les Paul*

<sup>5</sup> Image source: <http://www.seymourduncan.com/forum/showthread.php?244151-HSH-1-Volume-2-Push-Pull-Tone-5-Way>

<sup>6</sup>Image source: <http://shop.fender.com/en-US/electric-guitars/stratocaster/american-elite-stratocaster-hss-shawbucker/0114110723.html>

<sup>7</sup> Image source: [https://www.sweetwater.com/store/manufacture/Gibson/about/les\\_paul](https://www.sweetwater.com/store/manufacture/Gibson/about/les_paul)