

located near the 3rd node (from the nut) of the $n = 4$ harmonic, i.e. both located at $\frac{3}{4} \times 24\frac{1}{2}'' = 18\frac{3}{8}''$. Thus, here again, when playing open strings on a Les Paul with the pickup selector switched to the neck pickup, the 2nd harmonic (4th harmonic) will be enhanced (suppressed), respectively. The bridge PU on the Les Paul, like the Strat or Tele is not located near any anti-nodes or nodes associated with the low-order harmonics of the open strings.

From the above, one can see that the location of the pickups on electric guitars is such that the harmonic content of the signals output from the pickups tends to emphasize the higher harmonics, relative to the fundamental mode of vibration. This is one reason why electric guitars sound so much brighter in comparison to acoustic guitars.

Of course as soon as one plays notes and/or chords *anywhere* on the neck of an electric guitar, all of the above doesn't really matter - the pickup locations may or may not be at displacement nodes of harmonics for the notes being played - the resulting complex coloration of the tonal properties output from these guitars, along with the ability to select different pickup combinations and the ability to subsequently contour their sound using the tone & volume controls on the guitar and/or at the guitar amplifier is part of what makes them such a joy to play!

As mentioned above, because the transverse displacement(s), $y_n(x,t)$ of the harmonics associated with the triangle-shaped standing waves on plucked guitar strings go to zero at the bridge, a pickup located near the bridge should be overwound (slightly), to compensate for the loss of signal, relative to that associated with the signal output from the neck pickup, where the transverse displacements of the harmonics associated with the standing waves are larger. This is especially important for guitars with two or more pickups, in order to keep the overall sound from any choice of pickup, or pickup combination balanced. If one pickup has a significantly stronger, more powerful output than the other pickups on the guitar, the sound from this pickup will dominate when combined with any of the other pickups, limiting the versatility and variability of the tonal "dynamic range" that would otherwise be possible for this guitar, if it instead had balanced-output pickups. It is for this very reason that many guitar manufacturers do overwind (slightly) the bridge pickup, in order to achieve a balanced output between *e.g.* neck and bridge pickups on their guitars.

One final comment is that if it is desired to *maximize* the signal output from a given pickup on an electric guitar, the guitar player should pick/play the strings of the guitar *directly* over that pickup he/she has selected to play on. This is because the overall transverse displacement, $y(x,t)$ of the string(s) is a maximum precisely at that point, *because* of playing the strings at that point. Of course, from the perspective of maximizing tonal variation, a guitar player can obviously select any pickup or pickup combination, and play anywhere on the strings - near , or even on the neck for mellow tones, or, near the bridge, for brighter, more brilliant sounds, or, anywhere in between!