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DC resistance measurements are widely used as a gauge of the “output” of passive magnetic pickups. This use of DC resistance is both technically incorrect and often misleading; to find out why, read on…

In its most basic form a single coil magnetic pickup consists of a permanent magnet or set of magnets typically housed in an electrically insulating coil form (commonly referred to as a bobbin) and a coil of electrically insulated wire wound onto the bobbin (see Figure 1).

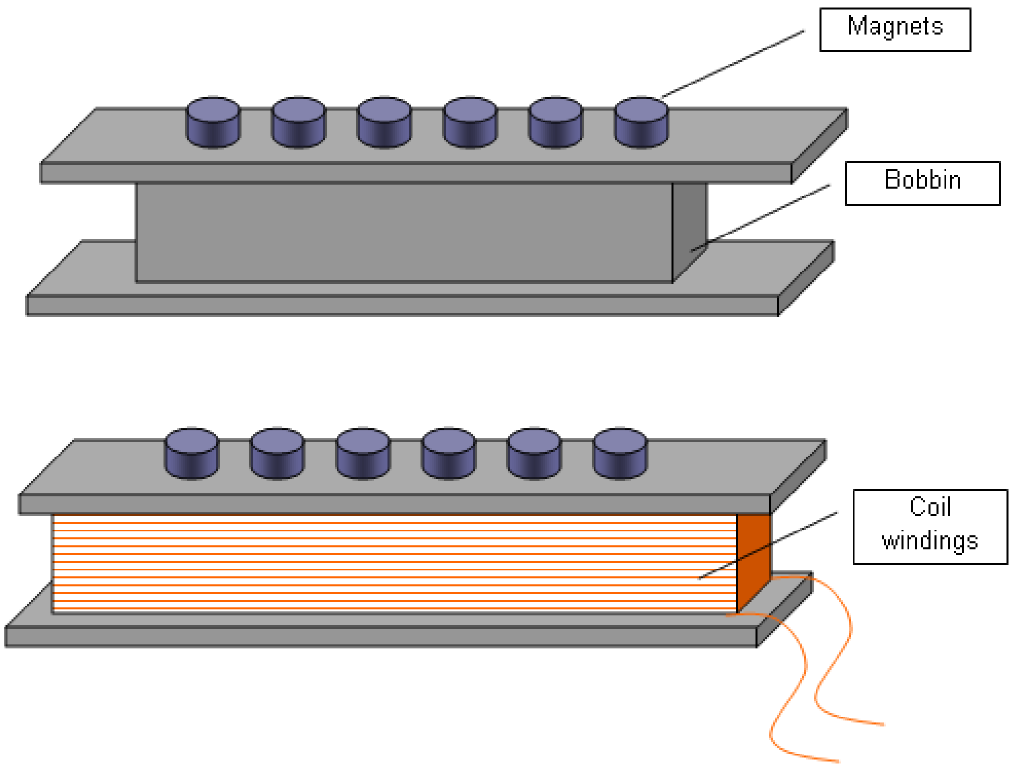

Figure 1. Simplified drawing of an unwound and a wound single coil pickup bobbin.

In operation, the vibrating strings of the instrument (which contain iron and nickel, both magnetic materials) cause the magnetic field of the pickup magnet(s) to fluctuate. This fluctuating magnetic induces free electrons in the coil windings to oscillate creating an alternating current (AC) signal which is the output of the pickup. Note that the pickup’s output is most often a complex AC waveform which may be characterized by its voltage and frequencies as shown in Figure 2.

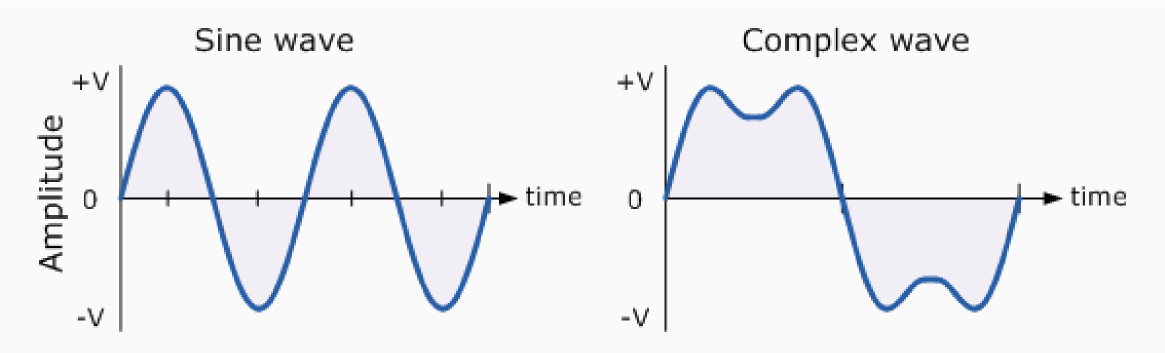

Figure 2. Simple and complex AC waveforms. In each plot the horizontal X-axis represents time [seconds] and the vertical, Y-axis represents voltage [volts].

Important fact #1: the output of a pickup is its peak to peak (+V and –V) voltage; the DC resistance of a pickup is not a measure of output.

Important Fact #2: The output of a passive magnetic pickup is predominantly a function of the number of turns on the coil, the geometry of the coil and the magnetic field strength of the magnets in the pickup.

In order to achieve the proper amount of gain, many turns of coil wire are wrapped on the bobbin; this number can range from 2,000 to over 10,000 in passive magnetic pickups. As a side note, active pickups which use a battery powered pre-amplifier to boost the signal can have fewer turns of coil wire. Within limits the output of a passive magnetic pickup increases with the number of turns on the bobbin.

The wire used in most modern guitar pickups is a small diameter electrically insulated copper wire ranging in wire size from 38 gauge [38 AWG (American Wire Gauge)] to 46 gauge [46 AWG] with the most commonly used sizes being 42 AWG and 43 AWG.

Coil wire used in pickups has an electrically insulating coating which prevents neighboring coil windings from creating a short circuit. The materials used to form this insulating coating have varied over the years and includes: enamel, Formvar, polyester and blends of other electrically insulating materials. In addition to the composition of the electrically insulating coating, the coating thickness plays a critical role in both the physical size of a wound coil and the tone of a completed pickup. Coating thicknesses are typically described as “Single Build” and “Heavy Build”. Data for the diameter of bare copper wire, wire with Single Build and Heavy Build and the resistance per 1,000 foot of length is presented in Table 1.

For reference, the mean diameter of human hair is approximately 0.004 inches.

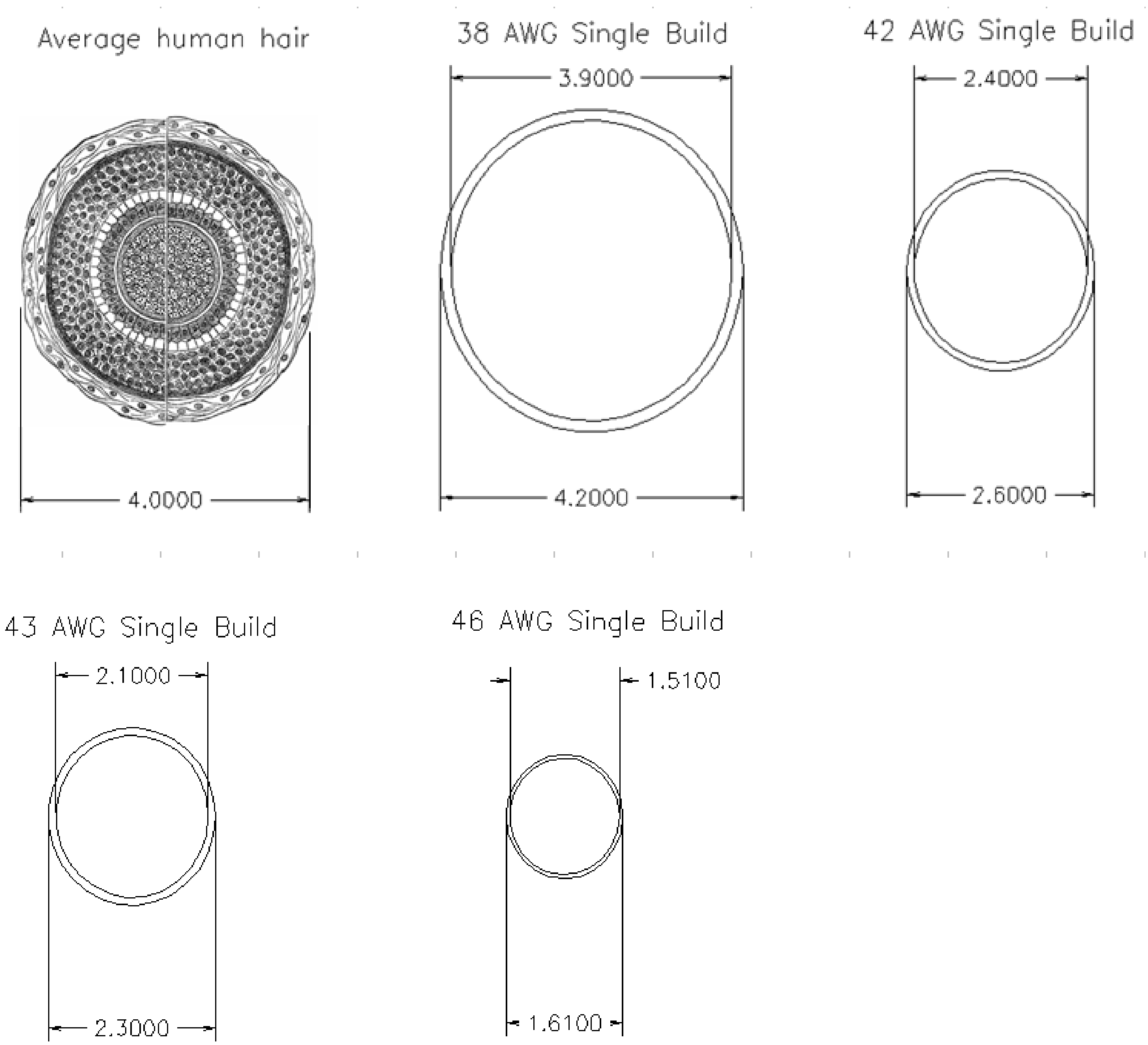

Figure 3. Scale drawing of cross sections of human hair and coil wires drawn to a scale of 1,000:1. In each drawing of coil wire cross sections both the diameter of the copper core and the diameter of the core plus the single build insulation is indicated.

Table 1: Data for copper wire sizes commonly used in magnetic pickups.

AWG	Bare Copper					
	Diameter, inches			Resistance, Ohms/1,000 ft		
	Minimum	Nominal	Maximum	Minimum	Nominal	Maximum
38	0.0039	0.004	0.0041	604.7	643.3	681.9
42	0.0024	0.0025	0.0026	1504	1652	1801
43	0.0021	0.0022	0.0023	1922	2137	2352
46	0.00151	0.00157	0.00164	3.87	4.207	4.544

AWG	Single build insulation			Heavy build insulation		
	Diameter, inches			Diameter, inches		
	Minimum	Nominal	Maximum	Minimum	Nominal	Maximum
38	0.0042	0.0045	0.0047	0.0046	0.0049	0.0051
42	0.0026	0.0028	0.003	0.0028	0.003	0.0032
43	0.0023	0.0025	0.0026	0.0025	0.0027	0.0029
46	0.00161	0.00173	0.00185	0.00181	0.00196	0.0021

Note that for samples of 1,000 feet of 42 and 43 gauge wire the DC resistances are 1.5 k-Ohm and 1.9 k-Ohm respectively.

A standard strat size neck position single coil pickup is often wound with 7,500 turns of 42 gauge wire with a resulting DC resistance of approximately 5.5 k-Ohm. From this DC resistance we can calculate that the length of the coil windings on this pickup is approximately 3,657 feet [almost 7/10ths of a mile!].

Winding an identical strat style pickup bobbin with 7,500 turns of 43 AWG wire would result in a DC resistance of approximately 7 k-Ohms. This DC resistance reading is 27% higher than the reading for the strat pickup wound with 42 gauge wire and yet the true output of these two pickups as measured in volts would be very similar.

Important fact #3: When comparing two similar pickups, using only the DC resistance measurement of the pickups may be a misleading indicator of the performance of a pickup.

Other factors which influence the DC resistance readings for pickups include the bobbin size and the degree of scatter-winding. As the length and width of a pickup bobbin increases the length of coil wire per turn on the bobbin increases. Charlie Christian style single coil pickups, for example tend to have a larger bobbin middle section where the coil windings are placed than tele neck position single coil pickups. As a result, a CC style pickup wound with the same number of turns of the same gauge wire as a tele neck position pickup would have a higher DC resistance. As a coil is wound on a bobbin the new coil windings are laid over the earlier windings and the bobbin size effectively increases such that a turn at the end of a coil can be up to 20% longer than the first turns on the bobbin.

Scatter winding is a term widely used to describe the “rastering” or side to side motion used in the process of winding coil wire onto a bobbin. Scatter winding can be slow, in which case the location of a turn of coil wire on a bobbin is close to that of its immediate predecessor and all of the windings are roughly parallel to each other. Fast scatter winding results in coil windings which are laterally displaced relative to the preceding coil windings and may be laid down at angles relative to each other. The DC resistance of a fast scatter wound coil can be significantly higher than that of a similar slow wound coil and yet the output of these two coils would be virtually identical.

In summary, DC resistance measurements of passive magnetic pickups, while relatively easy to make are often not a good gauge of the performance of pickups. To make a more complete comparison of pickups one should know the wire gauge used in the coil of each pickup, the number of turns on the coils and something about the strength of the magnets in the pickups.

I hope this information is helpful to you.

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