

# THE OUTPUT TRANSFORMER: What it does and how it affects tone

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The purpose of the output transformer is to "gear down" the tube output (which is mostly voltage swing with a little current flow behind it) into a signal that the speakers like to see which mostly current flow with a little voltage swing behind it. In this sense you can think of the output transformer as doing exactly the same job as the transmission does in your car: it matches the engine output (torque and RPM) to the rear wheels, so no matter how steep the hill is that you are climbing, the engine neither lugs down nor over-revs but always delivers the maximum power to the rear wheels. In this regard, output transformers with variable output impedance taps (2 ohm, 4 ohm, 8 ohm, 16 ohm) are just like 4-speed transmissions with different gear ratios for 1st, 2nd, 3rd and 4th.

To do this job, the transformer has to be wound with wire stout enough to handle the current flow without getting so hot that its insulation breaks down. Big power means thick wire to minimize heating, which increases the overall size of the transformer. The metal core of the transformer also has to be big enough so that it will not saturate until it is being hit with the very biggest signal that the tubes can put out. More power means more iron in the core. Both these effects mean that high power output transformers have to be big, which means heavy, which means expensive.

The primary (input) and secondary (output) windings inside the transformer are actually big coils wound around iron cores. Big power means big coils. In addition, to get good bass response, you have to make these coils as big as possible. However, big coils also necessarily restrict the passage of high frequencies and make the transformer more expensive, so the transformer designer has to trade off treble against bass and then balance this against transformer mass (= \$ cost). Hi-fi output transformers are specially designed to handle as much bass as possible while not restricting the passage of high frequencies. This makes them big and expensive. Guitar amp transformers are usually made to match the frequency output of the guitar, which carries not much bass nor many super-highs, and so will be smaller and less expensive than a hi-fi unit designed to carry the same amount of power. This is why high power tube bass amps have the biggest output transformers in the business, and low power guitar amps have much smaller output transformers.

A slightly small output transformer will saturate too soon and limit the output power to the speakers, especially at the power-hungry low frequencies. This effect helps the amp "shout" the highs better when it is turned all the way up but you also run the risk of frying the coils with too much heat. A slightly too big output transformer will not burn out but will boost the amp's bass-carrying capacity, which makes the tone a little bassier and darker. However, these tonal differences are easily adjusted for using the tone controls on the amp and by selecting speaker arrangements (4-10's versus 2-12's versus one 15, open back versus sealed back, heavy versus light cones, etc.).

The upshot? Organ output transformers are almost always overdesigned so they cannot distort even when running low frequencies (think organ pedals) at full rated power. This makes them big and heavy, but you don't generally have to carry an organ up and down stairs by yourself so mass isn't as important as low distortion. I use tube choice and number to determine how dirty the amp will play when it is running loud because these things have much bigger effects on tone than the design of the output transformer does.

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