Selecting Amplifier Output Transformers

by: Joe Ging, E.E.

One of the most commonly asked questions regarding commercial audio is: "Can I use a standard 70V or 25V speaker transformer to convert the output of an 8-ohm amplifier to a 70V or 25V speaker line?" The answer is given in the white paper that follows.

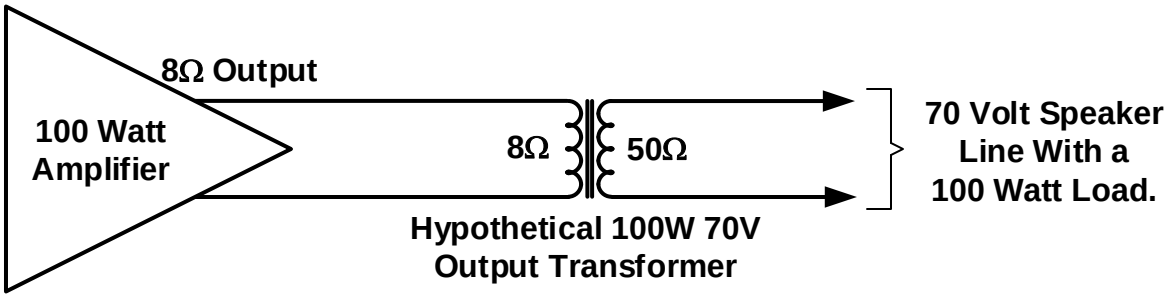
Note: Since we are talking about instantaneous AC values in audio, the calculations in the following white paper will be based on the standard Ohm's Law formulas:

$P = IV$ $P = V^2 / Z$ $P = I^2 Z$ Where P = Power, V = Voltage, I = Current, Z = Impedance.

Example 1 – A Perfect Impedance Match:

Let's start by looking at the ideal case using a 100 watt amplifier, where the 100 watt 70V output transformer is designed to perfectly match the 8-ohm output of the amplifier to a 70.7 volt speaker line. We can calculate the impedance of the transformer secondary:

$P = V^2 / Z$ so $Z = V^2 / P$ $Z = (70.7 \text{ volts})^2 / 100 \text{ watts} = 50 \text{ ohms}$



An amplifier should always feed a load that is greater than or equal to it's rated output impedance, for that load to be safe for the amplifier. Without getting deeply into transformer theory, let's just say that the turns ratio from the primary winding to the secondary winding "steps-up" or "steps-down" the voltage and the impedance. For our discussion, we are mostly interested in impedance (although a step-up in voltage will also be discussed). In the case of our ideal output transformer, the 8-ohms on the primary to the 50-ohms on the secondary, creates the ratio of "step-up" or "step-down". If we load that speaker line with speakers where the 70V transformer taps used add up to 100 watts, (which would be a 50-ohm load), we can calculate the load impedance the amplifier sees.

$$\frac{\text{50-ohm secondary}}{\text{8-ohm primary}} = \frac{\text{50-ohm load}}{X}$$

X = 8 ohms so the amplifier sees a perfect 8-ohm load.

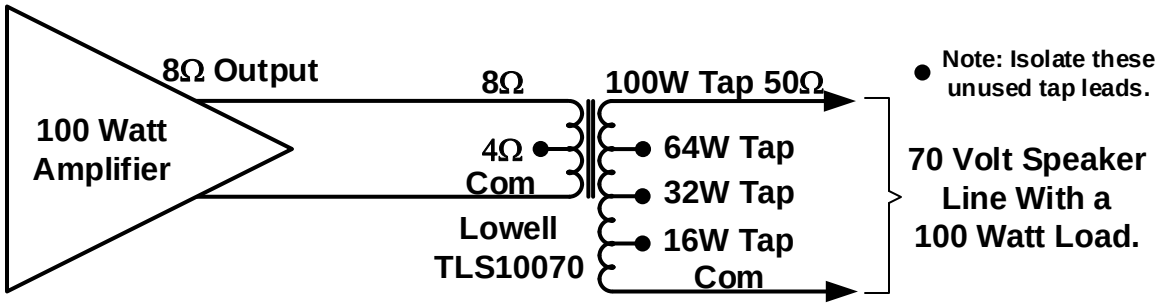
What if we load the 70V speaker line with only 50 watts of 70V speakers which would be a 100-ohm load? Then the calculation would be:

$$\frac{\text{50-ohms secondary}}{\text{8-ohms primary}} = \frac{\text{100-ohm load}}{X}$$

X = 16 ohms so the amplifier sees a safe load, but it will deliver only 50 watts to the load, not 100 watts.

In Summary for Example 1: If we load this ideal 70V output transformer with 100 watts of 70V speakers (which we know will have a combined impedance of 50 ohms), the 50-ohm to 8-ohm winding ratio results in the amplifier seeing a perfect the 8-ohm load, and the only loss is the insertion loss in the transformer. When the amplifier is turned all the way up, 70.7 volts is delivered to the speaker line.

Example 2 Can I use a standard 100 watt 70V speaker matching transformer, wire it in backwards, and use it for an output transformer? Answer: YES. As long as the 8-ohm tap is used to match the 8-ohm amplifier output, the 100W tap (that matches the amplifier power rating) is used for the 70V speaker line, and all unused tap leads are isolated, this will work just fine. The Lowell TLS10070 100W 70V transformer is used in our example:



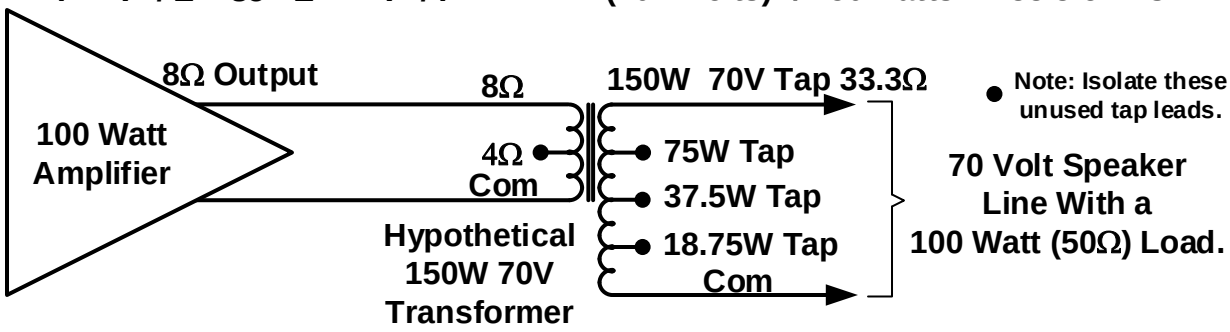
What if you want to use a transformer where the 70V tap power values don't perfectly match the power amplifier output rating?

Example 3 – Using a speaker matching transformer with a 70V power tap that is greater than the power rating of the amplifier:

We need to look at the impedance that the amplifier sees to find out if this is safe for the amplifier. See the hypothetical 150W 70V transformer below:

We know the impedance of the 150 watt transformer tap by using the formulas:

$P = V^2 / Z$ so $Z = V^2 / P$ $Z = (70.7 \text{ volts})^2 / 150 \text{ watts} = 33.3 \text{ ohms}$



Because of the power rating of the amplifier, we know we don't want to load the transformer with more than 100 watts of 70V speakers (which we know from "Example 1" will have a combined impedance of 50 ohms). The 33.3-ohm to 8-ohm winding ratio results in the amplifier seeing an impedance as calculated below:

$$\frac{\text{33.3-ohm secondary}}{\text{8-ohm primary}} = \frac{\text{50-ohm load}}{X} \qquad X = 12 \text{ ohms.}$$

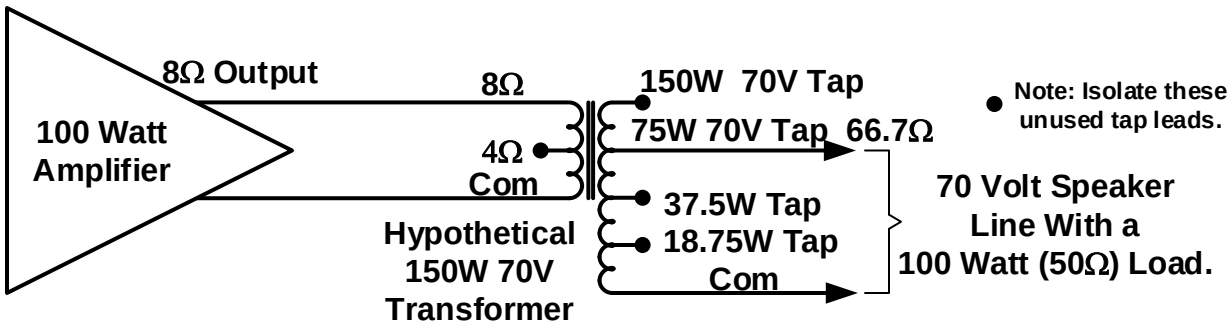
A 12-ohm load on an amplifier with an 8-ohm output impedance is safe for the amplifier, but what happens on the speaker line? That 8-ohm to 33.3-ohm winding ratio also affects the voltage on the speaker line. We know from "Example 1" that with an 8-ohm to 50-ohm winding ratio, that 100 watt amplifier through the transformer will develop 70.7 volts on the speaker line when the amp is turned all the way up. With an 8-ohm to 33.3-ohm winding ratio, the 100 watt amplifier will develop less than 70.7V when turned all the way up, so the speakers on the line will never reach the marked transformer power tap level.

Example 4 – Using a speaker matching transformer with a 70V power tap that is less than the power rating of the amplifier:

Again, we need to look at the impedance that the amplifier sees to find out if this is safe for the amplifier. See the hypothetical 150W 70V transformer below. For this example, we'll use that same 150 watt transformer, but we'll use the 75W tap instead.

We know the impedance of the 75 watt transformer tap by using the formulas:

$P = V^2 / Z$ so $Z = V^2 / P$ $Z = (70.7\text{volts})^2 / 75\text{ watts} = 66.7\text{ ohms}$



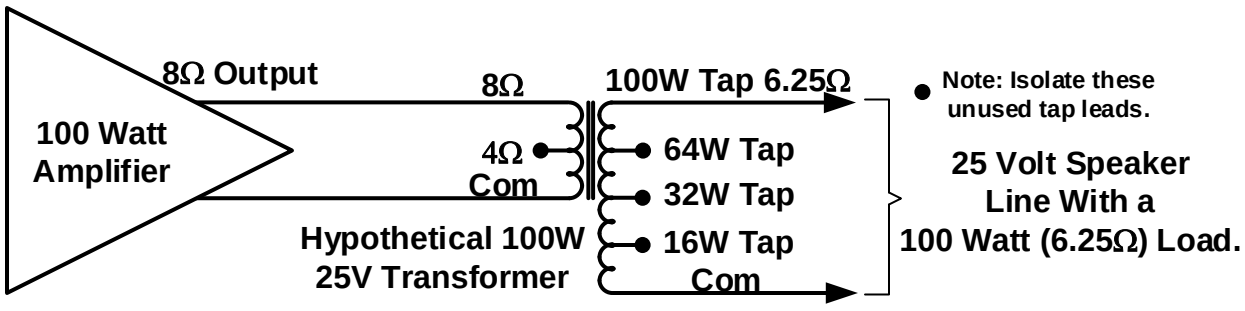
$$\frac{\text{66.7-ohm secondary}}{\text{8-ohms primary}} = \frac{\text{50-ohm load}}{X} \qquad X = 6\text{ ohms.}$$

Because of the power rating of the amplifier, we know we don't want to load the transformer with more than 100 watts of 70V speakers (which we know will have a combined impedance of 50 ohms). The 66.7-ohm to 8-ohm winding ratio results in the amplifier seeing a 6-ohm load, which will overload the 8-ohm output of the amplifier.

Example 5 – Same question for a 25V system: Can I use a standard 100 watt 25V speaker matching transformer, wire it in backwards and use it for an output transformer?

Answer: YES. As long as the 8-ohm tap is used to match the 8-ohm amplifier output, the 100W tap (that matches the amplifier power rating) is used for the 25V line, and all unused tap leads are isolated, this will work just fine.

$P = V^2 / Z$ so $Z = V^2 / P$ $Z = (25\text{ volts})^2 / 100\text{ watts} = 6.25\text{ ohms}$



$$\frac{\text{6.25-ohm secondary}}{\text{8-ohm primary}} = \frac{\text{6.25-ohm load}}{X}$$

X = 8 ohms so the amplifier sees a perfect 8-ohm load.

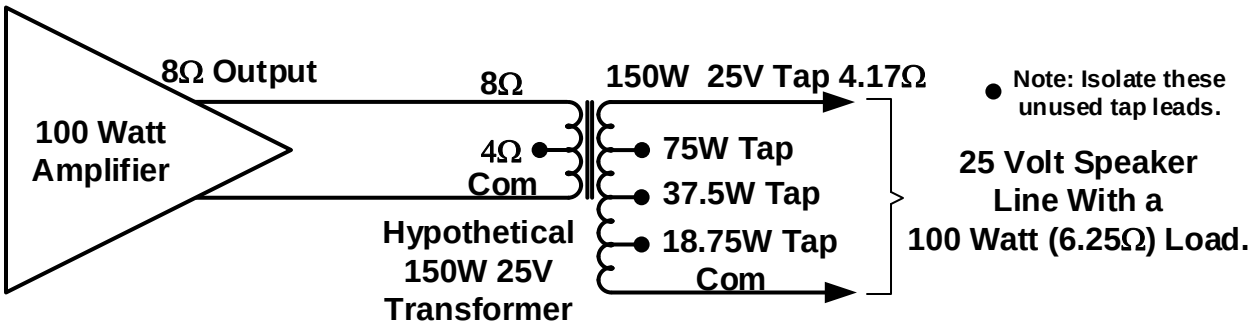
What if you want to use a transformer where the 25V tap power values don't perfectly match the power amplifier output rating?

Example 6 – Using a speaker matching transformer with a 25V power tap that is greater than the power rating of the amplifier:

We need to look at the impedance that the amplifier sees to find out if this is safe for the amplifier. See the hypothetical 150W 25V transformer below:

We know the impedance of the 150 watt transformer tap by using the formulas:

$P = V^2 / Z$ so $Z = V^2 / P$ $Z = (25 \text{ volts})^2 / 150 \text{ watts} = 4.17 \text{ ohms}$



Because of the power rating of the amplifier, we know we don't want to load the transformer with more than 100 watts of 70V speakers (which we know from "Example 5" will have a combined impedance of 6.25-ohms). The 4.17-ohm to 8-ohm winding ratio results in the amplifier seeing an impedance as calculated below:

$$\frac{\text{4.17-ohm secondary}}{\text{8-ohm primary}} = \frac{\text{6.25-ohm load}}{X} \qquad X = 12 \text{ ohms.}$$

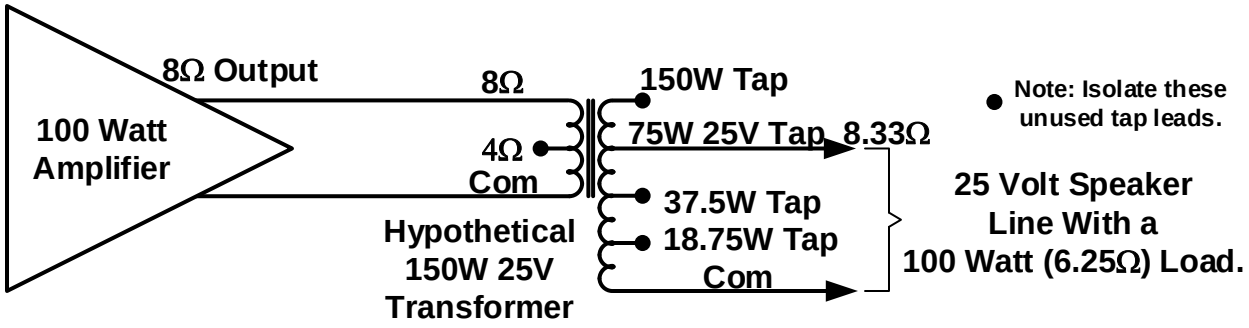
A 12-ohm load on an amplifier with an 8-ohm output impedance is safe for the amplifier, but what happens on the speaker line? That 8-ohm to 4.17-ohm winding ratio also affects the voltage on the speaker line. We know from "Example 5" that with an 8-ohm to a 6.25-ohm winding ratio, that 100 watt amplifier through the transformer will develop 25 volts on the speaker line when the amp is turned all the way up. With this 8-ohm to 4.17-ohm winding ratio, this 100 watt amplifier will develop something less than 25 volts, so the speakers on the line will never be driven to the power level marked on the power tap that is used.

Example 7 – Using a speaker matching transformer with a 25V power tap that is less than the power rating of the amplifier:

Again, we need to look at the impedance that the amplifier sees to find out if this is safe for the amplifier. See the hypothetical 150W 25V transformer below. For this example, we'll use that same 150 watt transformer, but we'll use the 75W tap instead.

We know the impedance of the 75 watt transformer tap by using the formulas:

$P = V^2 / Z$ so $Z = V^2 / P$ $Z = (25 \text{ volts})^2 / 75 \text{ watts} = 8.33 \text{ ohms}$



$$\frac{\text{8.33-ohm secondary}}{\text{8-ohms primary}} = \frac{\text{6.25-ohm load}}{X} \qquad X = 6 \text{ ohms.}$$

Because of the power rating of the amplifier, we know we don't want to load the transformer with more than 100 watts of 70V speakers (which we know will have a combined impedance of 6.25-ohms). The 8.33-ohm to 8-ohm winding ratio results in the amplifier seeing a 6-ohm load, which will overload the 8-ohm output of the amplifier.

White Paper General Conclusion:

Yes, you can use a standard 70V or 25V speaker transformer to convert the output of an 8-ohm amplifier to a 70V or 25V speaker line. The ideal speaker transformer to use would be one that has a transformer tap that is equal to the power rating of the amplifier. In that case, the amplifier will be able to produce 70.7V on the speaker line (in the case of a 70V transformer) when the amplifier is turned all the way up, or 25V on the speaker line (in the case of a 25V transformer) when the amplifier is turned all the way up. The load will be safe for the amplifier and the only loss will be the insertion loss of the transformer. If the transformer you want to use, does not have a transformer tap whose power value is equal to the power rating of the amplifier, always use an available transformer tap whose value is closest to but is greater than the power rating of the amplifier. This choice will be safe for the amplifier, but when the amplifier is turned all the way up, something less than a full 70.7 volts (or 25 volts in the case of a 25 volt transformer) will be available on the speaker line.

NEVER USE A TRANSFORMER TAP WHOSE POWER VALUE IS LESS THAN THE POWER RATING OF THE AMPLIFIER, BECAUSE THAT WILL OVERLOAD THE AMPLIFIER WITH AN UNSAFE IMPEDANCE, AND MAY DAMAGE THE AMPLIFIER.