Power Amp Output Impedance

INTRODUCTION

In the design of power amp circuits, the need often arises for a power amp model with specified output impedance. Most often, this requirement revolves around the need to accurately predict the phase performance of power amp circuits.

Output impedance of any op amp is modified by the feedback network present around the device. In voltage source type circuits, the effect of the network is to reduce the output impedance by a factor equal to the ratio of open loop gain to closed loop gain. In power amps, the net result is an effective output impedance of milliohm levels at frequencies below 1kHz. Wiring and interconnections often create larger impedances than the output impedance of the closed loop power amp. Therefore, output impedance will play a minor role in the phase performance at low frequencies. At high frequencies, reactive load considerations are already addressed by capacitive load specifications given on many power amplifiers.

Current control circuits, or current sources, include the load as a series element in the feedback loop with a sense resistor developing a voltage proportional to load current. Figure 1 shows a generalized example of just such a circuit. The load often consists of an inductive element such as a deflection yoke which can have up to 90° of phase shift at higher frequencies. Totally accurate prediction of phase in the feedback loop might at first seem to involve the series equivalent of output impedance and yoke impedance. In reality, it's because the feedback the op amp is operating as a true current source with an impedance approaching infinity. A realistic approach to stabilizing the circuit merely involves an auxiliary feedback whose effect dominates before the combination of yoke feedback and amplifier phase approaches 180°. Output impedance is not necessary to determine stability.

It is also important to realize that output impedance of a power op amp is not related in any way to power delivery capability or internal losses. A model of a power amp with the output resistance in series with the output will develop inordinate losses which are not observed in real world op amps.

Output impedance is dependent on several variables such as frequency, loading and output level. Often, the impedance will rise at higher frequencies. A class C amplifier, such as PA51 or PA61, will exhibit higher impedances at lower levels due to bulk emitter resistance effects in the emitter follower outputs.

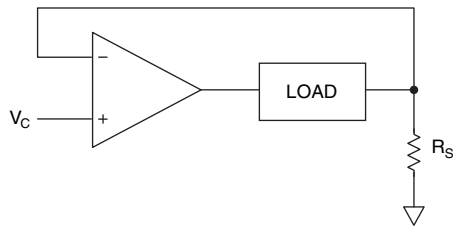

FIGURE 1. GENERALIZED CURRENT CONTROL CIRCUIT

OUTPUT IMPEDANCE MEASUREMENT

Several methods are available to measure output impedance. The simplest method is to measure open loop gain in loaded and unloaded conditions. This method measures the dynamic impedance in series with a perfect voltage source. Variations in output with loading are due to this impedance.

A more direct method is to generate a signal which is impressed into the output of an amplifier operating under open loop conditions. A measurement of current will determine the effective impedance that this signal is looking into.

ACTUAL IMPEDANCE VALUES

Several Apex Precision Power power amplifiers were measured using the gain variation with loading method. The test circuit of Figure 2 was loaded with 10 ohms. To establish uniformity of measurement, the smallest possible amplitude at 10Hz was used. Where a range of values is shown, it represents a range observed for several devices.

PA02: 10-15 ohms
PA07: 1.5-3 ohms
PA08: 1500-1900 ohms (high voltage amplifier)
PA09: 15-19 ohms
PA10: 2.5-8 ohms
PA12: 2.5-8 ohms
PA19: 30-40 ohms
PA51: 1.5-8 ohms
PA61: 1.5-8 ohms
PA84: 1400-1800 ohms (high voltage amplifier)

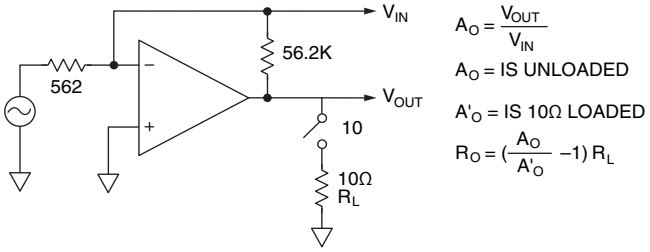

FIGURE 2. OUTPUT IMPEDANCE MEASUREMENT CIRCUIT

The high voltage amplifiers are much lower in current capability than the high current amplifiers. As a result, the higher impedance is to be expected.

The high impedance shown for PA19 is a result of the drain output MOSFET circuit without local feedback at the output stage. This is an example of how this parameter can be misleading. If 30 to 40 ohms of resistance were in series with the output, then the PA19 would never be capable of greater than 1 amp of output current. Under closed loop conditions, the output impedance is reduced to milliohm levels like any other power amplifier. Keep in mind the output impedance is an abstract term as far as output voltage and current capability are concerned.

To demonstrate the effect of output impedance when modeling, use the highest and lowest expected values. The results will verify that output impedance plays an insignificant role in power amp performance.

NEED TECHNICAL HELP? CONTACT APEX SUPPORT!

For all Apex Microtechnology product questions and inquiries, call toll free 800-546-2739 in North America.
For inquiries via email, please contact apex.support@apexanalog.com.
International customers can also request support by contacting their local Apex Microtechnology Sales Representative.
To find the one nearest to you, go to www.apexanalog.com