

TRIPATH CLASS-T AND DIGITAL AMPLIFIERS

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Tripath's sales and technical literature make frequent reference to "Class-T" amplifiers and "Digital amplifiers". This paper defines those terms and their use.

Amplifier Designations and Class-T

Amplifier circuits have traditionally been organized onto "classes" in order to provide an easy way to describe their basic operation. Terms such as "Class-A" and "Class-AB" are well known and have been used for at least 50 years. The classification method uses the output stage of the amplifier as it's defining characteristic. The input stage for a Class-A and a Class-AB amplifier might be identical, for example, but the difference in the operation of their output stages is the reason they are put into different classes.

More specifically, the classification is based on the amount of time the output devices are conducting during one cycle of a periodic signal. For example, an amplifier in which the output device is always "on", through both positive and negative voltage signal swings, is a Class-A amplifier. An amplifier which uses a complimentary pair of output devices and biases them such that they are never both on at the same time is referred to as a Class-B amplifier. Several other designations exist for audio and RF amplifiers whose output devices operate in their linear region.

Amplifier classification has also been applied to amplifiers which differ not in the operation of their output stages, but in the way the voltage rails change in response to the input signal. In a Class-G amplifier, two or more different power supply voltages are used per side, and the output devices are switched to the rail appropriate for the current signal level. The increased efficiency of this design provides size and weight advantages for a given power output, at the cost of a more complex power supply design. In the Class-H amplifier, the power supply rails track the input signal and maintain just enough voltage for proper operation. Increased efficiency is again the result. And, as with most other amplifier classes, these amplifiers operate their output devices in their linear range.

Another type of amplifier uses output devices which switch on and off several times during a half (or full) cycle of the input waveform. These devices switch at some fixed frequency, which is many times higher than the highest input frequency of interest. The output devices are switched in such as away as to yield, after low-pass filtering, a facsimile of the input signal, but with low output impedance and a higher voltage swing. This is the fundamental operating principle behind Class-D amplifiers. Class-D amplifiers are often used in circuits where linearity can be sacrificed for efficiency in operation. Incidentally, Class-D amplifiers, as designed today are really Class-S amplifiers, as Class-D designs employed a resonant filter to notch out the switching frequency. Class-S amplifiers used the current method of a low-pass filtering the output to remove the fundamental and it's harmonics. Over time, though, the term Class-D has come to be applied to any amplifier whose output devices are operated in switching mode.

Because the architecture, processing, and output signals bear little resemblance to a Class-D PWM design, the use of a separate designation for the Tripath amplifier (Class-T) is appropriate. While both Class-D and Class-T output stages integrate a pulse train to derive the output waveform, Class-T employs a totally unique approach to reduce noise and improve high frequency linearity. The differences include modulation of the switching frequency, dithering of the switching frequency, adjustment of the dead time, and other proprietary techniques. Tripath does not disclose the exact nature of its technology in order to protect its intellectual property.

As an example, in a Class-D amplifier, the designer is forced to trade off linearity for efficiency when the fixed switching frequency is chosen. In a Class-T amplifier the switching frequency is modulated in real time by the input amplitude. At low input levels, where high overall efficiency is not critical, the switching frequency is approximately 1.2MHz. This provides very good linearity. As the input level rises, the switching frequency drops to improve efficiency. At full-scale input, the switching frequency is approximately 200kHz.

Significantly, in all of the amplifier classifications used, the primary amplifier characteristics defined by the "Class" are linearity and efficiency. Put another way, the distinctions made between amplifiers of different classes are primarily efficiency and linearity (or both). Class-D amplifiers are characterized by high efficiency and poor linearity; Class-AB amplifiers, by good linearity and poor efficiency. It is for this reason that Tripath has adopted the use of the term "Class-T" to describe their amplifier architecture. Class-T amplifiers provide the high efficiency of Class-D amplifiers and the high linearity of Class-AB designs, while avoiding many of the problems associated with each of those topologies.

Digital Amplifiers

Tripath also uses the term “digital amplifier” to describe their implementation of switch-mode amplifiers. The term has been in popular use for some time, particularly since the advent of integrated Class-D control modules. In it’s current usage, “digital amplifier” refers to the method of using the output devices in switch mode, either completely on (in saturation) or completely off. It is this two-state operation that provides the exceptional efficiency exhibited by the Tripath amplifier. Since the output devices are either in a state where they are either conducting no current (off) or dropping very little voltage (on), they are never dissipating the high power levels common to linear designs.

Tripath uses the term Digital Power Processing™ to refer to the patented methods employed to switch the output devices in the ideal way to provide both high efficiency and high linearity. Standard Class-D designs have significant problems at higher frequencies with regard to noise, harmonic and intermodulation distortion, and filter construction. Tripath digital amplifiers solve these and other problems associated with Class-D.

In the future, Tripath will provide digital amplifiers in which the input signal remains in it’s native (digital) format all the way through the audio amplification stage, being converted back to analog only just prior to being delivered to the loudspeakers. These will be the first true digital amplifiers available for mass production in the general market.