mplifier classes Audio power amplifiers are classified according to the relationship between the output voltage swing and the input voltage swing, thus it is primarily the design of the output stage that defines each class. *Classification is based on the amount of time the output devices operate during one complete cycle of signal swing.* This is also defined in terms of output bias current [the amount of current flowing in the output devices with no applied signal]. For discussion purposes (with the exception of class A), assume a simple output stage consisting of two complementary devices (one positive polarity and one negative polarity) -- tubes (valves) or any type of transistor (bipolar, MOSFET, JFET, IGFET, IGBT, etc.).

- **class A** operation is where both devices conduct continuously for the entire cycle of signal swing, or the bias current flows in the output devices at all times. The key ingredient of class A operation is that both devices are always on. There is no condition where one or the other is turned off. Because of this, class A amplifiers in reality are not complementary designs. They are single-ended designs with only one type polarity output devices. They may have "bottom side" transistors but these are operated as fixed current sources, not amplifying devices. Consequently class A is the most inefficient of all power amplifier designs, averaging only around 20% (meaning you draw about 5 times as much power from the source as you deliver to the load!) Thus class A amplifiers are large, heavy and run very hot. All this is due to the amplifier constantly operating at full power. The positive effect of all this is that class A designs are inherently the most linear, with the least amount of distortion. [Much mystique and confusion surrounds the term *class A*. Many mistakenly think it means circuitry comprised of discrete components (as opposed to integrated circuits). Such is not the case. A great many integrated circuits incorporate class A designs, while just as many discrete component circuits do not use class A designs.]
- **class B** operation is the opposite of class A. Both output devices are never allowed to be on at the same time, or the bias is set so that current flow in a specific output device is zero when not stimulated with an input signal, i.e., the current in a specific output flows for one half cycle. Thus each output device is on for exactly one half of a complete sinusoidal signal cycle. Due to this operation, class B designs show high efficiency but poor linearity around the crossover region. This is d ue to the time it takes to turn one device off and the other device on, which translates into extreme crossover distortion. Thus restricting class B designs to power consumption critical applications, e.g., battery operated equipment, such as 2-way radio and other communications audio.
- **class AB** operation is the intermediate case. Here both devices are allowed to be on at the same time (like in class A), but just barely. The output bias is set so that current flows in a specific output device appreciably more than a half cycle but less than the entire cycle. That is, only a small amount of current is allowed to flow through both devices, unlike the complete load current of class A designs, but enough to keep each device operating so they respond instantly to input voltage demand s. Thus the inherent non-linearity of class B designs is eliminated, without the gross inefficiencies of the class A design. It is this combination of good efficiency (around 50%) with excellent linearity that makes class AB the most popular audio amplifier design.
- **class AB plus B** design involves two pairs of output devices: one pair operates class AB while the other (slave) pair operates class B.

- **class C** use is restricted to the broadcast industry for radio frequency (RF) transmission. Its operation is characterized by turning on one device at a time for less than one half cycle. In essence, each output device is pulsed-on for some percentage of the half cycle, instead of operating continuously for the entire half cycle. This makes for an extremely efficient design capable of enormous output power. It is the magic of RF tuned circuits (flywheel effect) that overcomes the distortion create d by class C pulsed operation.
- **class D** operation is switching, hence the term *switching power amplifier*. Here the output devices are rapidly switched on and off at least twice for each Sampling Theorem. Theoretically since the output devices are either completely on or completely off they do not dissipate any power. If a device is on there is a large amount of current flowing through it, but all the voltage is across the load, so the power dissipated by the dev ice is zero (found by multiplying the voltage across the device [*zero*] times the current flowing through the device [*big*], so 0 x big = 0); and when the device is off, the voltage is large, but the current is zero so you get the same answer. Consequently class D operation is theoretically 100% efficient, but this requires zero on-impedance switches with infinitely fast switching times -- a product we're still waiting for; meanwhile designs do exist with true efficiencies approaching 90%.
- **class E** operation involves amplifiers designed for rectangular input pulses, not sinusoidal audio waveforms. The output load is a tuned circuit, with the output voltage resembling a damped single pulse.

The following terms, while generally agreed upon, are not considered "official" classifications

- **class F** [If the person from Motorola Communications Division (I believe) who wrote me with all the great input re broadcast amp classes, could write me again. I would appreciate it. I did all the suggested edits, then promptly threw away your suggestions, forgot to save the file, and lost them all! Write me (Dennisb@rane.com). Thanks!]
- **class G** operation involves changing the power supply voltage from a lower level to a higher level when larger output swings are required. There have been several ways to do this. The simplest involves a single class AB output stage that is connected to two power supply rails by a diode, or a transistor switch. The design is such that for most musical program material, the output stage is connected to the lower supply voltage, and automatically switches to the higher rails for large signal peaks [thus the nickname *rail-switcher*]. Another approach uses two class AB output stages, each connected to a different power supply voltage, with the magnitude of the input signal determining the signal path. Using two power supplies improves efficiency enough to allow significantly more power for a given size and weight. Class G is becoming common for pro audio designs. [Historical note: Hitachi is credited with pioneering class G designs with their 1977 *Dynaharmony HMA 8300* power amplifier.]
- **class H** operation takes the class G design one step further and actually modulates the higher power supply voltage by the input signal. This allows the power supply to track the audio input and provide just enough voltage for optimum operation of the output devices [thus the nickname *rail-tracker*]. The efficiency of class H is comparable to class G designs. [Historical note: Soundcraftsmen is credited with pioneering class H designs with their 1977 *Vari-proportional MA5002* power a mplifier.]