RF Power Amplifier Classes of Operation

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Amplifier operation is distinctly different depending on the class of operation.

RF amplifiers are classified "A", "AB", "B" or "C" according to the phase-angle over which 'plate' or 'collector' current flows. (Phase-angle is the number of degrees of current flow during each 360-degree RF cycle)

Class A Amplifiers

Class "A" amplifiers operate over a relatively small portion of a tube's plate-current or a transistor's collector-current range and **have continuous plate,** collector or drain **current flow throughout each 360-degree RF cycle.** Their efficiency in converting DC-source-power to RF-output-power is poor. DC source power that is not converted to radio frequency output power is dissipated as heat. However, in compensation, Class "A" amplifiers have greater input-to-output waveform linearity *(lowest output-signal distortion)* than any other amplifier class. They are most commonly used in small-signal applications where linearity is more important than power efficiency, but also are sometimes used in large-signal applications where the need for extraordinarily high linearity outweighs cost and heat disadvantages associated with poor power efficiency.

Class B Amplifiers

Class "B" amplifiers have their tube control-grids or transistor bases biased near plate- or collector current cutoff, causing **plate,** collector or drain **current to flow during 180 degrees of each RF cycle.** That causes the DC-source-power to RF-output-power efficiency to be much higher than with Class "A" amplifiers, but at the cost of severe output cycle waveform distortion. That waveform distortion is greatly reduced in practical designs by using relatively high-Q resonant output "tank" circuits to reconstruct full RF cycles.

The effect is the same in principle as pushing a child in a swing through half-swing-cycles and letting the natural oscillatory characteristics of the swing move the child through the other half-cycles. However, low sine-wave distortion results in either case only if the Q of the oscillatory circuit (*the tank circuit or the swing*) is sufficiently high. Unless the Q is infinite, which it never can be, the amplitude of one-half cycle will be larger than the other, which is another way of saying there always will be some amount of harmonic energy. *(Coupling an antenna system too tightly to the resonant output tank circuit of an amplifier will lower its Q, increasing the percentage of harmonic content in the output.)*

Another effective method commonly used to greatly reduce Class "B" RF amplifier output waveform distortion (*harmonic content*) is to employ two amplifiers operating in "push-pull" such that one conducts on half-cycles where the other is in plate- or collector-current cutoff. Oscillatory tank circuits are still used in the outputs of Class "B" push-pull amplifiers to smooth switching transitions from the conduction of one amplifier to the other, and to correct other nonlinearities, but lower-Q tank circuits can be used for given percentages of harmonic content in the output. *(Tank circuits can be loaded more-heavily for given percentages of harmonic output where two amplifiers operate in push-pull.)*

Class AB Amplifiers

Class "AB" amplifiers are compromises between Class "A" and Class "B" operation. They are biased so **plate,** collector or drain **current flows less than 360 degrees, but more than 180 degrees**, of each RF cycle. Any bias-point between those limits can be used, which provides a continuous selection-range extending from low-distortion, low-efficiency on one end to higher-distortion, higher-efficiency on the other.

Class "AB" amplifiers are widely used in SSB linear amplifier applications where low-distortion and high power-efficiency tend to both be very important. Push-pull Class "AB" amplifiers are especially attractive in SSB linear amplifier applications, because the greater linearity resulting from having one amplifier or the other always conducting makes it possible to bias push-pull Class "AB" amplifiers closer to the Class "B" end of the "AB" scale where the power-efficiency is higher. Alternatively, push-pull Class "AB" amplifiers can be biased far enough toward the highly-linear Class "A" end of the scale to make broadband operation without resonant tank circuits possible in applications where broadband operation or freedom from tuning is more important than power-efficiency.

Sub class numbers (AB1 & AB2) scheme is a simple one, with a "1" indicating that the electron tube does not draw any grid current, and "2" indicating that the electron tube output stage grid voltage is being pushed above the 0 volt mark and into a positive grid voltage, causing the grid to draw some current from the preceding driver stage.

Class C Amplifiers

Class "C" amplifiers are biased well beyond cutoff, so that **plate,** collector or drain **current flows less than 180 degrees of each RF cycle.** That provides even higher power-efficiency than Class "B" operation, but with the penalty of even higher input-to-output nonlinearity, making use of relatively high-Q resonant output tank circuits to restore complete RF sine wave cycles essential. Class "C" amplifiers are commonly used in Interrupted Continuous Wave (ICW), Frequency Shift-Keyed (FSK) Radio Teletype (RTTY), and Angle Modulated [Frequency Modulated (FM) and Phase Modulated (PM)] transmitter applications where signal amplitudes remain constant. High amplifying-nonlinearity makes them unsuitable to amplify Amplitude Modulated (AM)[(Double Side Band (DSB), or Single Side Band (SSB)] signals. **Any amplifier after a signal has already been Amplitude Modulated must be class "A", "AB" or "B".** However, most Class "C" amplifiers can be directly amplitude-modulated with acceptably low distortion by varying plate-voltage or collector-voltage, because they generally are operated in the region of plate-saturation or collector-saturation so that the RF output voltage is very closely dependent upon instantaneous DC plate-voltage or collector-voltage.