App-Note: 002 - Amplifier Classification A vs. AB

Amplifiers are designed in many ways. One distinction is how the amplification devices are biased. They can be biased in different ways that affect performance and efficiency. This is called the Class of operation. Class A, B, or AB are commonly used and referred to in specifications for high power RF & Microwave amplifiers. We discuss in this paper the differences between the different classifications and what it means with respect to performance. There are more classes of operation Class C, D, E… these are less common, and custom designed for individual tasks where high efficiency and linearity are not a concern.

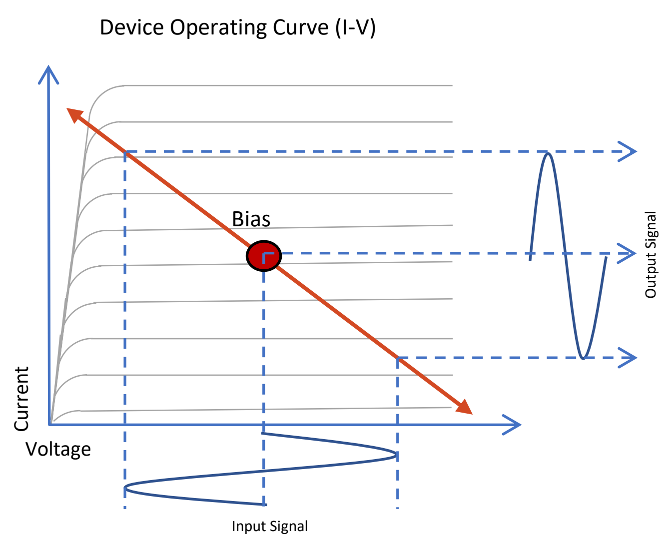
What is meant by bias? An amplification device such as LDMOS, MOSFETs, GaN, or GaAs are the heart of the amplifier. Having properties and frequency response, manufacturers choose or develop based on these for the frequency band, power & application. Each device, however, needs to be biased; it is set at a voltage and current at its steady state. The setting of this bias is what now determines its classification.

Class Comparisons

Class	A	B	AB
Conduction Angle	360°	180°	Between 180° to 360°
Bias Position	100% on	0% off	Between 0% to 100%
Overall Efficiency	25 to 30%	70 to 80%	50 to 70%
Linearity Performance	Best	Cross over distortion	Good

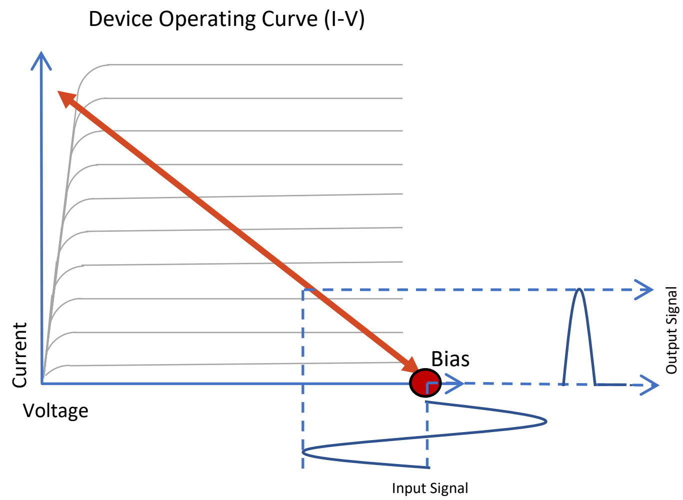
Class A

Class A is biased full ON drawing the most current at its voltage per device, allowing a full 360° swing of the RF signal through each device. Class A can offer a simple design with good linearity, but this comes at the cost of running hotter and is less efficient. More heat is generated and must be cooled, and a larger power supply also must be used to compensate for the inefficiency. These requirements increase the size and cost of the unit. Since the unit does run hotter, the life of the amplifier is reduced. However, overdesign of heat handling can extend the life.



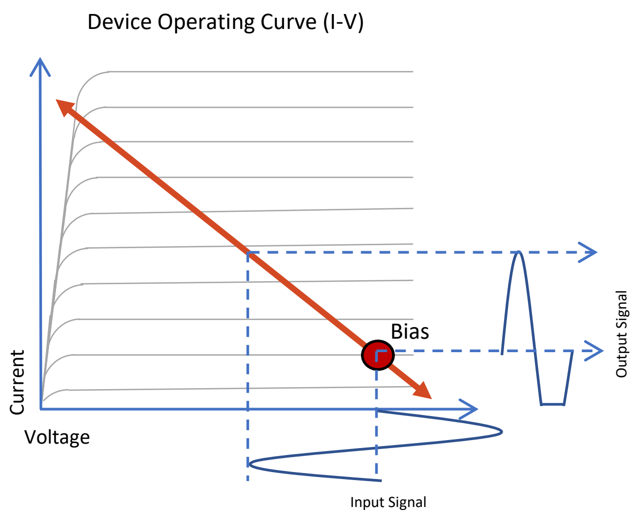
Class B

Class B is biased full OFF drawing the least amount of power through the device. Each device only allows a 180° swing of the RF signal. Devices are paired together to allow one for positive swing and one for negative swing 180°+180°=360°. Where the devices "shake hands" at the zero crossings can produce distortion. Some audio and lower frequency amplifiers used this technology. However, when frequency coverage is needed above 1 MHz, it becomes more & more difficult to engineer a useful instrument. Since the amplifier is efficient, heat is less of an issue.



Class AB

Class AB Is biased in between a Class A and a Class B amplifier, which many regard as the best compromise. The device is biased at >180° and paired with another device, the same as for Class B, but now there is an overlap between the 2 devices correcting the issue of cross over distortion. These 2-device configurations are called a push-pull. The cross over distortion is resolved, but some distortion does remain as the overlap is never perfect. Since the efficiency can be over 2X better than a class A amplifier, the benefits out-way this minor difference. Compared to Class A less heat is generated, and less power is required reducing the size and cost of the final amplifier instrument.



Robustness

Robustness is an amplifiers' ability to handle poor loads or mismatches that produce a high VSWR (See Exodus VSWR app-note 001). Or, work well in severe environmental conditions such as high heat or dusty areas. It is sometimes thought that Class A amplifiers are more robust than other amplifiers. However, this is a myth. The overall design of the amplifier is what allows it to be more robust. Class A amplifiers must be built with a lot of heat dissipation and larger power supplies which can lead to better robustness, but Class AB amplifiers can also be over-designed for meeting the same requirements while still offering efficiency. Other factors play a role in performance like; device technology and fabrication, circuit design, power combining techniques, connectors, and cooling. It all comes down to engineering the amplifier to the right or appropriate conditions and/or application.

Conclusion

Amplifiers can be designed and built to meet the requirements of the application. Some applications require linearity and robustness. Care should be taken when selecting an amplifier to make sure it can work in the application. Whether it is Class A or AB does not determine this characteristic, but rather how it is engineered for the task.