



Application Note 114: The Real Facts for Class A vs. AB Amplifiers for EMC Applications

Class A Amplifiers:

Class A amplifiers operate over a relatively small portion of a transistor's drain-current range and have continuous drain-current flow throughout each 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 comparison, Class A amplifiers have greater input-to-output waveform linearity (*lower harmonics known as 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 are sometimes used in large-signal applications where the need for extraordinarily high linearity outweighs cost and heat disadvantages associated with poor power efficiency.**

Note: Reflections occur whether an amplifier is Class A or AB due to High VSWR common in EMC Applications. Class A operation reduces the longevity and reliability of a high power amplifier system due to the high heat dissipation and constant stress. Class A amplifiers see additional stress and dissipation in High VSWR applications as the additional reflected power is additive to the higher dissipation already present in a Class A configuration.

Class AB Amplifiers:

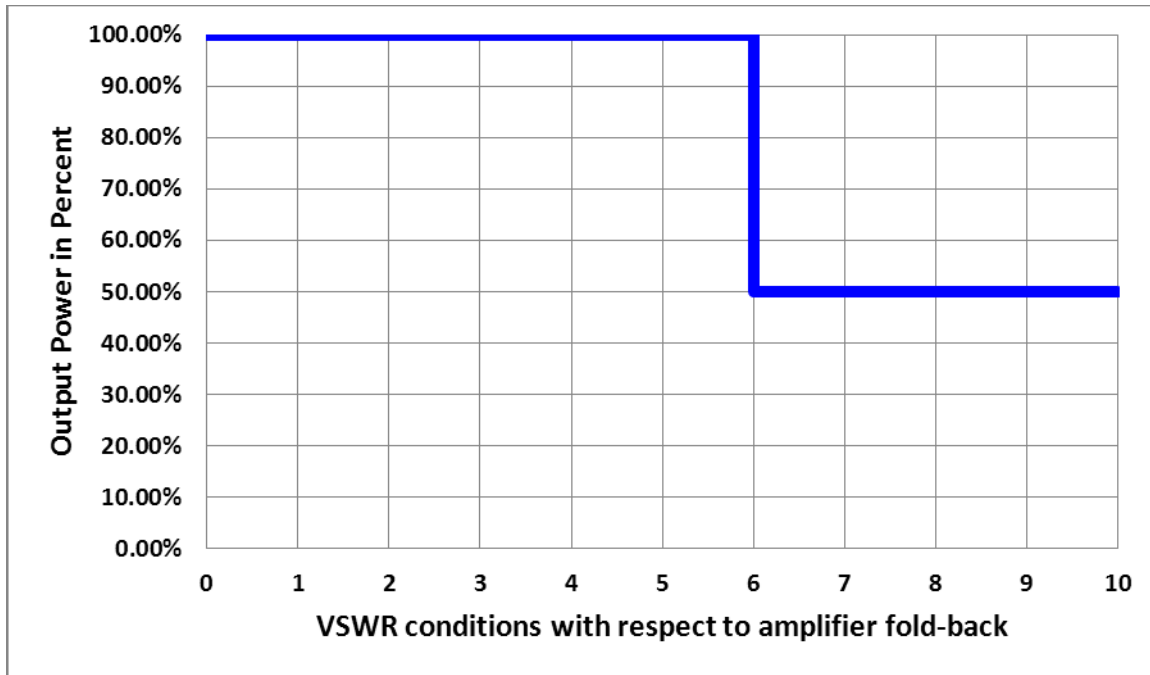
As the designation suggests, Class AB amplifiers are compromises between Class A and Class B operation. They are biased so drain-current flows less than 360 degrees, but more than 180 degrees, of each RF cycle. Any bias-point between those limits can be used which provides a continuous selection-range extending from low-distortion, low-efficiency on one end to higher-distortion, higher-efficiency on the other. Class AB amplifiers are widely used in linear amplifier applications where low-distortion and high power-efficiency tend to both be very important such as in EMC Applications. Push-Pull Class AB amplifiers are especially attractive in 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 close enough to the Class A end of the AB scale where the linearity is very good as well as the power-efficiency being higher. **These push-pull Class AB amplifiers can be biased far enough toward the linear Class A end of the scale to make broadband operation possible where reduced harmonics (low output signal distortion) is as important as power-efficiency.**

Note: IFI does produce some Class A amplifiers as they are appropriate for some lower power levels and applications. Our Amplifiers that are Class AB, they are biased "Bias plus Class AB", meaning that for RF amplitudes up to approximately -3dB below the P1dB point, the Transistors operate predominantly Class-A. From approximately -3dB up to Saturation, the Transistors are operating Class-AB. This "Bias plus Class-AB" mode has been successfully and is predominantly used for EMC amplifier systems, communications, component and Industrial applications as these also require very good linearity and harmonic reduction coupled with the advantages of improved efficiency over Pure Class-A operation. This reduces operating costs in high power test facilities and increases the long term life / availability of the amplifier due to the increased efficiency over pure Class-A operation.

Amplifier VSWR ruggedness is addressed in terms of IFI's typical "3dB-over-silicon", meaning that the transistors are operated at 50% of their specified rating. In addition to keeping the drain current lower, the amplifier is designed to fold-back under very high reflective loads. For open/short circuit VSWR conditions, field loads would not be exposed to the DUT and the test would be ineffective with the reflected power coming back into the amplifier. Class AB amplifiers are ideal in these situations as they will protect themselves which greatly improves the long-term reliability, performance and continual operational use of the amplifier. In essence, the IFI solution is a 50/50 Class A-AB taking the best overall advantages of both classes of operation. Figure 1 illustrates the "Bias-Plus Class AB" power curve.



Figure 1: Power Fold-Back Curve for our Class AB amplifier design



Class A Amplifiers:		Class AB Amplifiers:	
Pros	Cons	Pros	Cons
Best Linearity	Very Poor Efficiency	Good Linearity	Limited Dynamic range~30dB
Lowest Distortion (low harmonics)	Maximum Heat Dissipated	Low Distortion (low harmonics)	Higher Band-Pass Ripple at low power levels
Broad Bandwidth	Larger Size	Broad Bandwidth	
Low Band-Pass Ripple at all power levels	More transistor devices needed	Low Band-Pass Ripple	
Low to Medium Power		Up to Multi-Kilowatt Power	
		Good Efficiency	
		Compact Size	
		Relatively Cool Operation	
		Less transistor devices needed	

Summary Analysis:

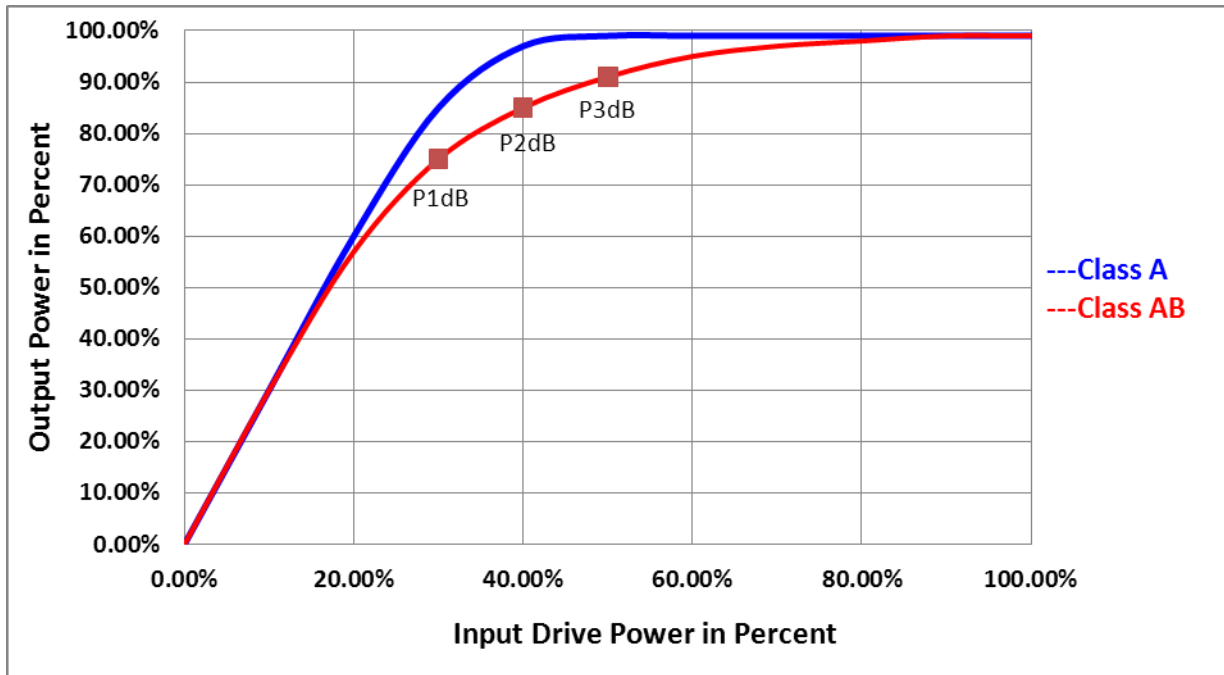
Class A amplifiers provide good linear amplification but have very poor DC to RF power conversion efficiency; they are a larger amplifier size producing maximum heat dissipation.

Class AB amplifiers provide good linear amplification have good DC to RF power conversion efficiency; they are a more compact amplifier design and have proven to be an excellent solution and compromise with lower heat dissipation thereby providing excellent reliability.



Figure 2: Linearity Chart for Class A vs. AB amplifier design

Illustrating Harmonic Distortion & Compression



Harmonic Content (output signal distortion):

Class A amplifiers provide good linear amplification for the operating area on the Class-A straight line up to Rated Power. The 2nd harmonic is typically -25 to -35dBc (the industry standard is normally -20dBc for most test applications). The in-band 3rd harmonic is typically -22 to -30dBc. Harmonic content beyond the P1dB point increases in a non-linear manner.

Class AB amplifiers provide good linear amplification for the operating area on the Class-A straight line up to the P1dB point. The 2nd harmonic is typically -25 to -35dBc (the industry standard is normally -20dBc for most test applications). In a Class-AB push-pull configuration, the 3rd harmonic is typically -22 to -24dBc before driving the amplifier beyond the P1dB point. Harmonic content beyond the P1dB point increases in a non-linear manner due to the start of the deviation off the straight line linearity curve. Out of band Harmonics are attenuated due to the natural roll-off of the linear amplifier.

EMC testing is routinely accomplished using Class AB amplifiers in their linear region. There is no difference with respect to the results using either amplifier class being that the difference in Harmonic content (non-linearities) are virtually equal for EMC applications. **Class AB amplifiers are ideal for these EMC Application as they will protect themselves which greatly improves the long-term reliability, performance and continual operational use of the amplifier. In essence, the IFI solution is a 50/50 Class A-AB taking the best overall advantages of both classes of operation.**

IMPORTANT NOTE: Output distortion products (Harmonics/output signal distortions) increase non-linearly for any amplifier Class once you exceed the P1dB point. Therefore a Class A or AB Amplifier will operate in a manner that the tests can be accomplished with the same results for EMC testing applications.