Measuring IP2

Measuring the second order intercept of a high performance preamplifier can be difficult. In many cases, even high quality test equipment falls short without auxiliary filters.

This page describes how Clifton Laboratories measures IP2.

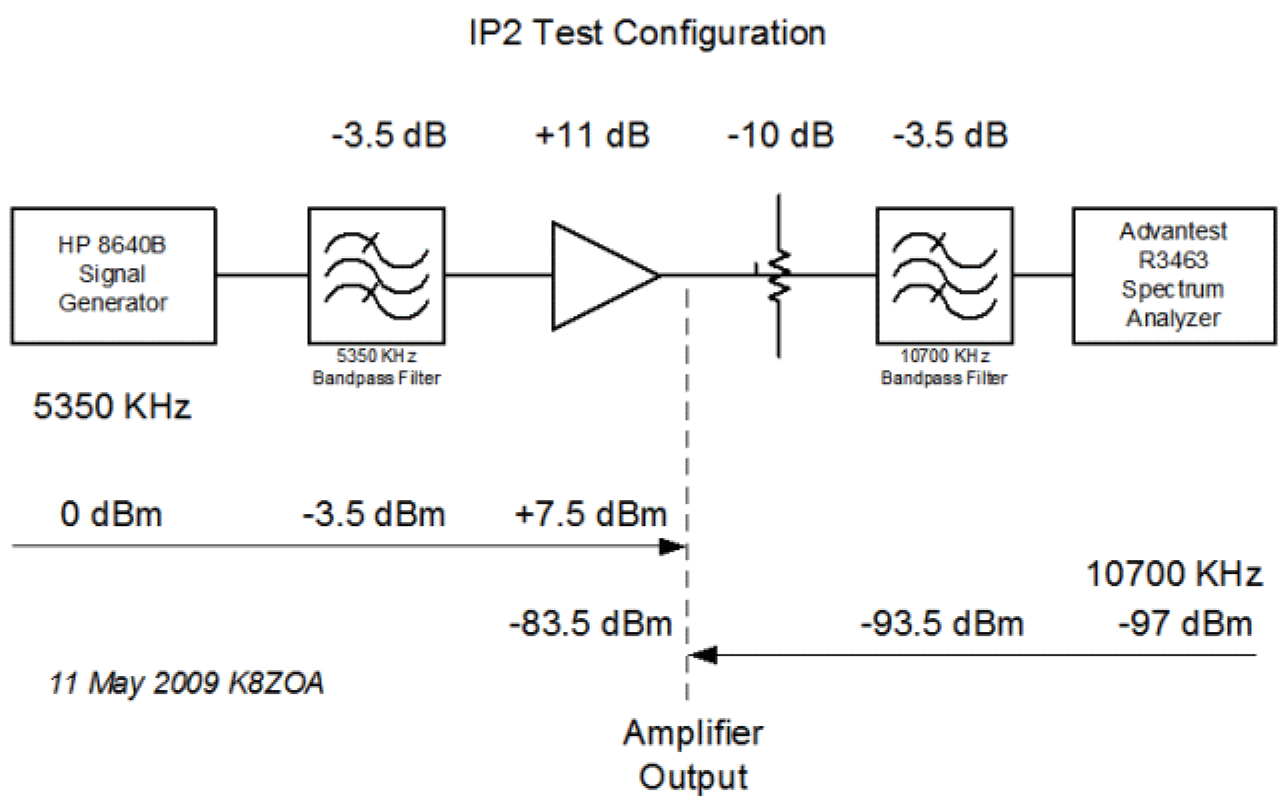
What is IP2? IP2 is the abbreviation for "intermodulation intercept, 2nd order." I've described what IP2 is at Z10040A Norton Amplifier and will not repeat it here.

One commonly recommended IP2 test procedure duplicates the IP3 "two tone" process; apply two equal test signals at frequencies f1 and f2 and measure the level of the second order intermodulation product, located at f1+f2. The second order intercept is then f1's signal level plus the difference between f1's signal level and the f1+f2 product.

Although this setup has the advantage of permitting IP2 measurements with the same setup used for IP3, it's overly complicated.

In fact, IP2 stays the same if f1 and f2 are identical in frequency. Hence, we can use a single signal generator, not two. (If you don't believe me, you may wish to read http://www2.rohde-schwarz.com/file_1349/1MA71_1e.pdf). In essence, you inject a very clean signal into the amplifier and measure the second harmonic. The difference between the fundamental and second harmonic signal levels then is used to calculate IP2.

The test setup I use to measure the Z10040A Norton amplifier and other amplifiers is shown below.



In measuring amplifiers with high IP2 values, the spectrum analyzer is the limiting factor; it will generate its own second harmonic. In addition, even a very good signal generator will have a second harmonic 60 dB or so down from the fundamental.

Two bandpass filters are necessary to increase the dynamic range of the IP2 measurement process.

First, a bandpass filter on the signal generator output. (A low pass filter work just as well, but I don't have a suitable low pass filter.) The test frequency is 5350 KHz and the bandpass filter reduces the second harmonic by approximately 60 dB. The HP8640B's second harmonic is down 60 dB, so the net is an amplifier input test signal with the second harmonic down approximately 120 dB.

Second, a bandpass filter on the spectrum analyzer input. (A high pass filter would work just as well, but I don't have a suitable high pass filter.) This filter, centered at 10700 KHz in my test setup, is necessary to prevent the strong 5350 KHz signal from overloading the R3463 spectrum analyzer and generating spurious second harmonics. In order to ensure the amplifier under test sees a 50 ohm termination at both the fundamental and second harmonic, a 10 dB attenuator at the amplifier's output is necessary.

In calculating the IP2, it is necessary to reference the various signal levels to a common point, the amplifier output.

Thus, the fundamental is:

Signal generator output

- bandpass filter loss

+amplifier gain.

In this example:

Signal generator output = 0 dBm at 5350 KHz

5350 KHz bandpass filter loss 3.5 dB

Amplifier gain: 11 dB.

Thus the amplifier under test has a 5350 KHz output of +7.5 dBm.

Likewise, we go backwards from the spectrum analyzer towards the amplifier output:

The second harmonic is:

Spectrum analyzer level measurement

+bandpass filter loss

+attenuator

In this example:

Spectrum analyzer reads 10700 KHz signal at -97 dBm

+3.5 dB 10700 KHz bandpass filter loss

+10 dB attenuator

Thus, referenced back to the amplifier output, the 10700 KHz signal level is -83.5 dBm.

The harmonic is thus 91 dB below the fundamental or the "harmonic ratio" is 91 dB.

IP2 is calculated as:

Fundamental + harmonic ratio.

In this example:

+7.5 dBm + 91 dB = +98.5 dBm

Hence, the Z10040A tested has an IP2 of +98.5 dBm.