Lab Exercise O: Measurement of Third Order Intercept

In Project III, you measured noise, which will limit the smallest signals your receiver can detect. In this project, you will characterize the distortion of the downconverter, which limits the largest signal you can detect. You will first measure the third order intercept point of each component and then calculate the expected third order intercept of the entire downconverter. You will then verify the calculation by measurement.

Prelab
There is no prelab work required for this lab.

Procedure

![Diagram of downconverter elements for OIP3 measurement](image)

Figure 4.1 Grouping of downconverter elements for OIP3 measurement

Divide the downconverter as shown in Figure 4.1. Characterize each of the three groups individually.

1) Set up the equipment as shown in Figure 4.2 except add some fixed attenuators between the sources and the combiner. 3dB pads should be enough. This keeps one source from mixing with the other due to nonlinearities in the gain control sections of the sources. Such nonlinearities of the test equipment can create erroneous results.

2) Select two in-band RF frequencies, \(f_1\) and \(f_2\), whose third order products are also in the bandwidth of the receiver.

3) Connect the spectrum analyzer to the output of the attenuator and set the attenuation to -10 dB (you will use the attenuator from -10 dB to -60 dB to ensure a good match throughout your measurements). Adjust the sources so that their output powers are equal and at -10 dBm. Check that the attenuator accurately decreases the source power. Use a power meter to make some spot checks of the spectrum analyzer measures.

4) Attach the device under test between the spectrum analyzer and the attenuator. Vary the attenuator and record the input power, the power in the fundamental tones, and the power in the third order products.
5) Turn off one of the sources. Using the attenuator vary the single tone power input to the device under test. Record both the input and output power for levels up to the 1 dB gain compression point, $P_{1\text{dB}}$.

6) Plot the output powers versus the single tone input power all in dBm. Note that the power in the third order products increases with a 3:1 slope while the power in the fundamental tones increases 1:1. Mark the input power where $P_{1\text{dB}}$ occurs on the plot. Draw a best fit line with 3:1 slope through the third order data and a best fit line with 1:1 slope through the points denoting the power at the fundamental. The output power where these lines intersect is the output referred third order intercept point (OIP3). Mark it on your plots.

Follow this procedure for each of the three sections of your downconverter, as noted in Figure 4.1. When measuring the mixer, you will, of course, have to use a third source (HP8648C) as an L.O. and the fundamental and 3rd order products that you will be observing will all be near 60 MHz (rather than 915 MHz for the LNA). When measuring the IF block, both the input and output signals will be in the vicinity of 60 MHz.

Measure the OIP3 of the entire downconverter in a similar manner. From your measurements of the individual components calculate the expected OIP3 for the downconverter and compare to measurements.

Make a table with a column for each group of components and where the first row contains all the OIP3 values of each group in the downconverter. Make the second row the gains of each group. In the third row divide the OIP3 of each group by the total gain from the input of the downconverter to the output of the component in question. This is the third order intermodulation intercept referred to the input of the downconverter. The reciprocal of the sum of the reciprocals of these values is the input referred third order intercept of the downconverter (IIP3). Multiplying this value by the downconverter gain gives the output referred third order intercept. Note that the IF amplifier determines the intercept point of the downconverter.

![Figure 4.2 Equipment set-up for measurement of third order intercept](image-url)
**Equipment Required**

- Spectrum Analyzer
- 2 RF Sweepers
- HP8648C Synthesizer
- Variable Attenuator
- Power Combiner (MiniCircuits)
- Low Noise amplifier 1-1000 MHz (MiniCircuits ZFL-1000LN)
- Band Pass filter 915 +/− 34 MHz (K&L filter)
- Mixer (MiniCircuits ZFM-5X)
- Band Pass Filter (MiniCircuits SIF-60)
- IF amplifiers (MiniCircuits ZFL-500)