

Two-Tone IP3 Measurement

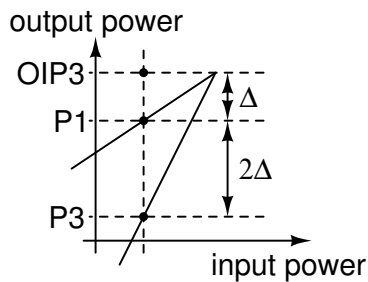
Introduction

In this lab you will measure the output third-order intercept point (OIP3) of a Mini-Circuits ZX60-3018G RF amplifier using the two-tone method.

Third-order intermodulation products appear at frequencies near the input signals and are the most likely to cause interference both within the same channel and to adjacent channels.

The level of third-order products increases three times faster than those of the fundamental components when the signal levels are expressed in dB. The output power when the two powers would be equal is called the output third-order intercept point (OIP3).

As shown in the diagram below, when the output level is Δ dB less than the OIP3 the third-order intermodulation components will be 3Δ less than OIP3:

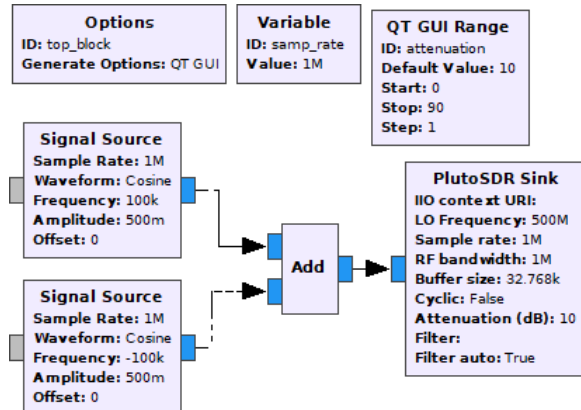


Thus measuring the output level, P1 (dBm) and the relative level of the third-order product, $2\Delta = P1 - P3$ (dB) allows us to compute OIP3 as $P1 + \Delta$.

Procedure

Two-Tone Transmitter

Use Gnu Radio Companion (GRC) to create the following flowgraph of a two-tone transmitter:



The complex signal sources have amplitudes of 0.5 and frequencies of +100 kHz and -100 kHz:

ID	analog_sig_source_x_0_0
Output Type	Complex
Sample Rate	samp_rate
Waveform	Cosine
Frequency	-100e3
Amplitude	0.5
Offset	0

This puts one carrier (“tone”) offset by 100 kHz on each side of the 500 MHz center frequency. The sampling rate and RF bandwidth are set to 1 MHz. The RF output level is attenuated by the variable attenuation:

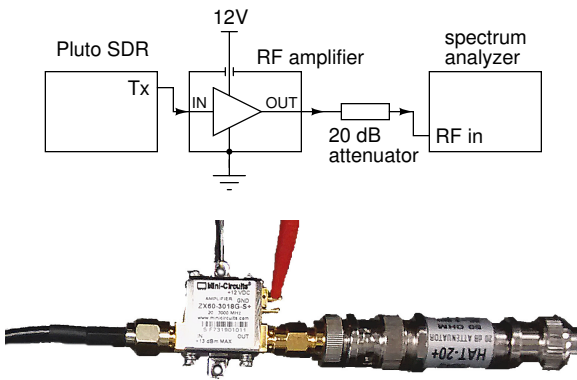
ID	pluto_sink_0
IIO context URI	
LO Frequency	500e6
Sample rate	samp_rate
RF bandwidth	samp_rate
Buffer size	6x8000
Cyclic	False
Attenuation (dB)	attenuation
Filter	
Filter auto	True

which is set by a GUI Range control that selects a value between 0 and 90 dB:

ID	attenuation
Label	
Type	Float
Default Value	10
Start	0
Stop	90
Step	1
Widget	Counter + Slider
Minimum Length	200
GUI Hint	

Grab a screen capture of your flowgraph to use in your report.

Measurement Setup



Connect the Pluto SDR TX output to the IN port of the amplifier using the short SMA-to-SMA cable included in the kit. Connect the amplifier's OUT port to a **20 dB attenuator**¹ using an SMA-to-BNC adapter. Connect the attenuator to the spectrum analyzer with a BNC cable.

Adjust a DC power supply to 12 V with current limiting at 50 mA (600mW). Because of the cost of the amplifiers and the ease with which they can be destroyed by incorrect supply voltages, **have the instructor check your setup** before connecting power to the amplifier.

Spectrum Analyzer Configuration

Set the spectrum analyzer to default settings using the buttons and menu items: **Shift** - **8** (System) / System Options / Reset / Factory Defaults.

Configure the spectrum analyzer using the buttons and menu items shown below:

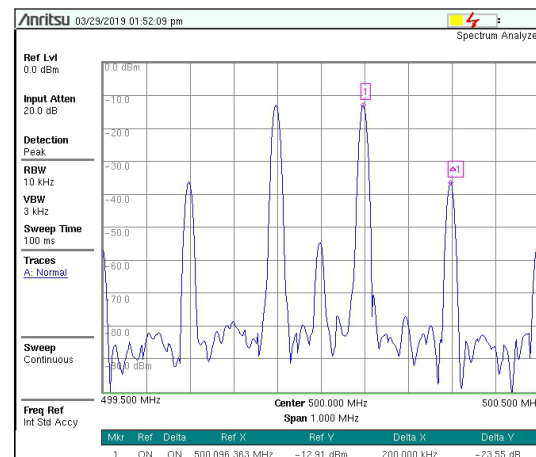
Freq / Center Frequency / 500 MHz
Amplitude / Reference Level / 0 dBm
Span / Span / 1 MHz
BW / RBW: 1 kHz
 / VBW: 30 Hz

Measurements

Run the GRC flowgraph. You should see a spectrum similar to (but not the same as) the following

¹The maximum SDR output (10dBm) and the maximum amplifier gain (25dB) results in a level that exceeds the maximum input level of the spectrum analyzer (23 dBm with < 10 dB attenuation).

with two carriers offset by 100 kHz on either side of 500 MHz and third-order intermodulation products 200 kHz away from those.



To measure the levels of the intermod products, set a marker on one tone and measure the difference to the IM3 product using the following menu items:

Marker / Marker (1)
 / On (On)
 / Delta (On)
 / Peak Search
 / More Peak Options
 / Next Peak Right
 (repeat until at correct peak)
 / More / Marker Table (On)

Increase the SDR output attenuation in steps of 5 dB until the intermod products are close to the spectrum analyzer's the noise floor. Record the marker 1 level ($P_1 = \text{Ref Y}$) and the different in level between the markers ($P_1 - P_3 = 2\Delta = \text{Delta Y}$) as shown in the marker table.

Capture one of the measurement screens to a file following the instructions in a previous lab (do not use a camera).

Analysis

Organize your measurements in a table showing the attenuation, the fundamental level in dBm, the difference between successive fundamental levels, the relative level of the third-order intermod and the estimated OIP3 including the effect of the 20 dB attenuator. For example:

	A	B	C	D	E
1	attenuation:	20	dB		
2					
3	attenuation	P1	increase	$P1-P3 = 2\Delta$	OIP3
4	dB	dBm	dB	dB	dBm
5	20	-22		-60	28
6	15	-17	5	-43	24.5
7	10	-13	4	-23	18.5
8	5	-11	2	-15	16.5

Compare the results to the manufacturer's specifications as given in the datasheet.

Lab Report

Before the end of the lab, submit a lab report to the appropriate dropbox that includes the following:

- the usual identification information
- a screen capture of your GRC flowgraph
- one spectrum analyzer screen capture
- a table showing your measurements and calculations including the computed OIP3 corrected for the 20 dB attenuator
- a sentence or two stating your estimate of the amplifier's OIP3 and how it compares to the manufacturer's specifications
- a list of additional losses and sources of measurement error that are not included in your result