ECE145B/218B | **Lab Exercise #1** | S. Long
Winter 2011 | Amplifier and Mixer Evaluation | Due 1/24

## Part 1. Large Signal Amplifier Characterization.

Amplifiers all experience gain compression or expansion, harmonic distortion or intermodulation distortion at large signal levels. This lab will characterize one of the amplifiers that you built in ECE145A or ECE218A. If you do not have this amplifier now, you can perform this lab on the Minicircuits LNA that is included in your tool kit.

BE SURE YOUR AMPLIFIER IS DC BLOCKED AT BOTH INPUT AND OUTPUT!!!!

See Fig. 1. Use the spectrum analyzer to determine

*On all of these measurements: record the spectrum analyzer settings (RBW, Ref Level, Span) with the data.*

**A.** $P_{1dB}$ and harmonic distortion

1. Measure small signal gain at a frequency within the useful range of your amp that is low enough that you can measure at least a second harmonic on the spectrum analyzer.
2. Increase input power and determine the 1dB compression input power level.
3. At this power level, determine the output power at all harmonic frequencies that can be seen on the spectrum analyzer. List the HD/ fundamental Pout ratios in dB in a table.

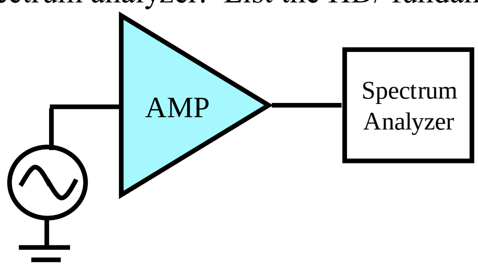


Figure 1. Use generator output attenuator to adjust amplifier input power.

**B**. Intermodulation distortion and IIP3.

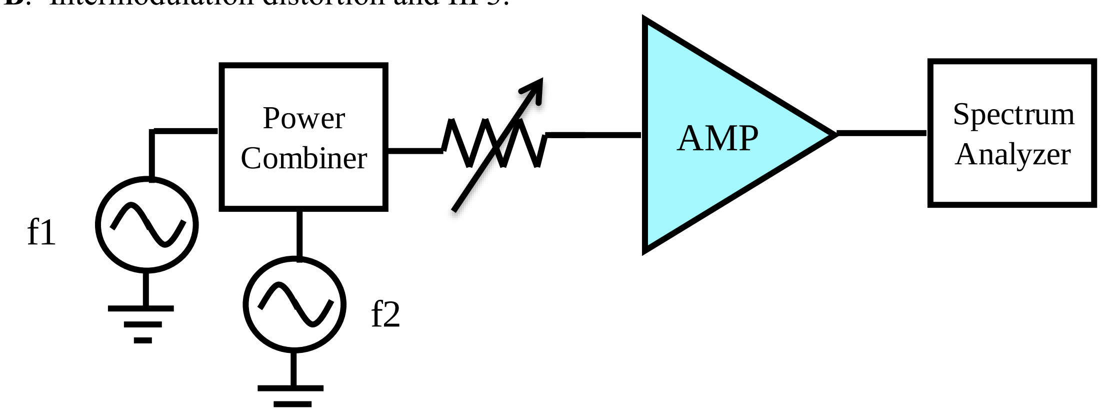


Figure 2. Use two generators to test for intermodulation behavior. Set both generator powers equal and sum together with an isolating power combiner (ZSC-2-1 is in your toolbox - see datasheet on website). Use a step attenuator to decrease or increase the total power level at the input of the amplifier.

1. Choose f1 and f2. The third order IMD will be visible at 2f1 - f2 and 2f2 - f1. Set the total power of both signals at least 20 dB below P1dB and reduce the resolution bandwidth and span of the spectrum analyzer so that the IM3 is clearly visible.

2. Measure the ratio of f1 or f2 to IMD power as a function of input power in 1dB steps. Make sure the slope of the IMD power vs input power is approximately 3. Calculate the IIP3 from this measurement. If the slope differs much from 3, reduce the input power level further and try again. Does your calculated IIP3 vary with input power? Compare IIP3 with P1dB.

**Report.** Summarize your measurement results. Describe the measurement conditions used for each part above. The report should be short – not a design report.

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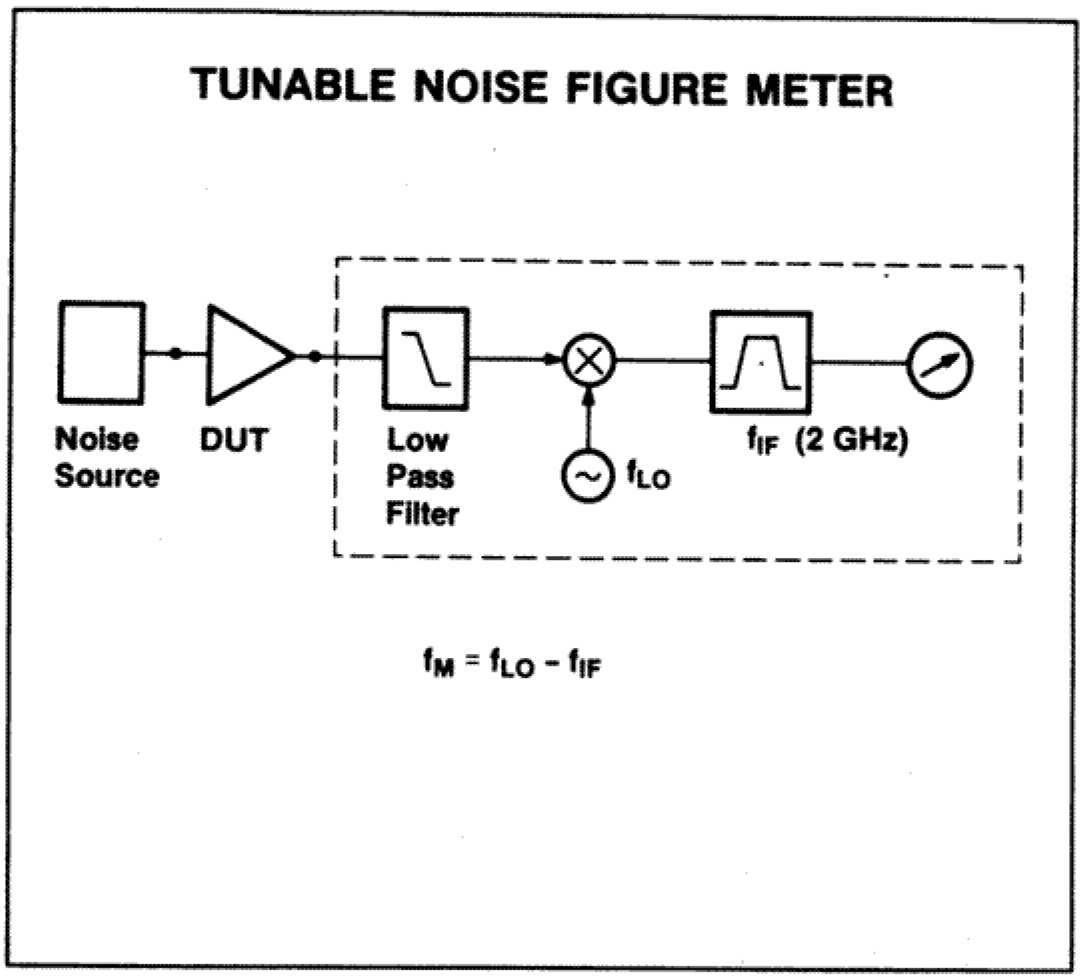
## Part 2. Noise Figure Measurement




The noise figure measurement setup consists of a wideband noise source and a tuned receiver. Your amplifier is the DUT (device under test). The noise source is switched on and off by the

NF meter so that the NF is calculated by the Y factor method. Small signal gain is also displayed.

The use of the meter will be demonstrated in lab prior to your measurement.

**Part 2.** Measure and record your amplifiers NF and SS gain at a midband frequency. (Note that the measurement can be affected by other signal sources in the lab. If you are getting readings that seem much too high, ask your neighbor to turn off their generator and see if it changes)

**Report.** Summarize your measurement results. Describe the measurement conditions used for each part above. The report should be short – not a design report.

## Next go to part 3.

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## Appendix 1.

Data on Minicircuits LNA.

| Parameters | Specs |
|---|---|
| **Frequency Range** | 0.1 - 500 MHz |
| **Gain** | 24 dB |
| **1 dB compression (output)** | +5 dBm |
| **Noise Figure** | 2.9 dB |
| **IP3** | +14 dBm |

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* **Absolute Maximum Ratings: Mini-Circuits ZFL-500LN LNA**
* Max. RF Input Power (no damage): +5 dBm
* DC input voltage: 15 volts
* Be very careful about synthesizer power adjustment so that this maximum level is
* not exceeded. The amplifier is expensive!

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# Part 3: Mixer Characterization

**Goal:** Characterize double balanced mixer large signal performance.

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* **Absolute Maximum Ratings for Mini-Circuits ZAD-1 Mixer**
*     LO Power:     +10 dBm
*     RF Input Power:     +13 dBm
* Be very careful about synthesizer power adjustment so that these maximum levels are
* not exceeded. The mixer is expensive!
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* **Frequency Range:**
*     RF/LO     0.5 to 500 MHz
*     IF     DC to 500 MHz
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This mixer can be found in your toolbox. The data sheet is on the course website.

**Part 3. Mixer Evaluation.** Apply a 250 MHz, +7dBm sine wave to the local oscillator input (L) of the Mini-Circuits ZAD-1 mixer. Measure this signal on the spectrum analyzer first to account for cable loss and verify its power level and spectral content. Connect the spectrum analyzer to the IF output of the mixer.

*On all of these measurements: record the spectrum analyzer settings (RBW, Ref Level, Span) with the data.*

a. Connect the second generator to the RF input of the mixer. Set the mixer input RF signal amplitude to – 20 dBm. Select an RF input frequency that will produce a downconversion output at 50 MHz. Determine the conversion loss at both down and upconversion output frequencies.

b. Change the RF input to the image frequency. Record frequencies and show that the conversion losses are essentially the same.

c. Measure the 1 dB gain compression point for the mixer.

d. Measure the conversion loss of the mixer as a function of LO input power starting from 7 dBm and reducing the LO power in 3 dBm increments. Explain why the loss increases when the LO drive is reduced.

e. Restore the LO power to +7 dBm. Measure the LO to IF and RF to IF isolation. Then, connect the spectrum analyzer to the RF port and measure LO to RF isolation.

f. Reconnect the spectrum analyzer to the IF port. With the RF input power close to the 1 dB compression point, set the reference level of the spectrum analyzer so that the largest output from the mixer is close to the top of the screen. Reduce the resolution bandwidth so that the noise level is less than -70 dBm. Record the frequency and amplitude of all IF output frequencies up to the $5^{th}$ order. Explain how each frequency was generated (for example, a $4^{th}$ order product would be $3f_{LO} + f_{RF}$).

**Report.** Summarize your measurement results. Describe the measurement conditions used for each part above. The report should be short – not a design report. Address each of the steps a.-f. above in the report.