Chapter 3

Lab 3 - Broadband Amplifier

3.1 Background Information

The introduction and the background information on the amplifier was passed out in a short electronic and a hard-copy distribution. The handout included the design information and component selection procedure. The information on amplifier construction and s-parameter measurements was given in class. This handout primarily focuses on non-linear measurements. For the background, the students are referred to class note packet.

3.2 Lab 3 Session 3 Tasks

3.2.1 Stability Circles

This task can be done outside of the lab session. For the write-up, the only required stability circles are at frequencies of 10, 55, and 100 MHz, but the students are encouraged to look at a broader range of frequencies.

In order to plot stability circles for your measured S-parameter data, do the following:

Create a new data display window. Call it "AmpStabCirc". Place the following items:

- An equation, starting with n = 0
- An equation, SourceCircle = s_stab_circle(S) [Note, S is the measured 2-port s-parameter data]
- An equation, LoadCircle = l_stab_circle(S)
- Plot SourceCircle and LoadCircle on Smith Charts
- Double click on the Smith Chart, highlight the trace name (either SourceCircle or LoadCircle), click "Trace Options", go to "Trace Expression", change it from SourceCircle to SourceCircle[n,::], or LoadCircle to LoadCircle[n,::]. Adjusting the n value will give you the stability circles at different frequencies.
- Make sure the amplifier is, at least, conditionally stable for Γ_S and Γ_L at the center of the Smith chart and a good area around the center.

3.2.2 Measuring Gain Compression with the E8357A VNA

Gain compression can be observed and characterized by setting up the VNA to operate at a fixed frequency while sweeping the input power over a defined range. The instrument will show a plot of insertion power gain in dB ($20 \log |S_{21}|$) verses input available power level in dBm. The gain will be relatively constant at very low input powers, and will decrease as the input power increases.

1. Select the "power sweep" mode: [Sweep][Sweep Type], select "Power Sweep". Set desired start and stop power. Set CW freq to 50 MHz.
2. Go to the [Channel][Power] menu and set Attenuation to 20 dB.
3. The instrument will display gain vs. input power (actually, P_{avs}). Find the input power level at which the gain has decreased by 1 dB from the small-signal value. This is the input power for 1 dB compression.

3.2.3 Two-tone Measurement for Intermodulation Distortion

1. Connect the outputs of two signal generators to a signal combiner/splitter (labeled PSC2-1). Ports 1 and 2 serve as inputs for this experiment.
2. Take the output of the combiner from the port marked 'S'. This signal will be used to drive the amplifier.
3. Setup for the VSA:
   Center Frequency: 50 MHz
   Span: 200 kHz
   Resolution VBW: 300 Hz.
4. Setup for the function generators: RF Output should be less than -20 dBm (For two-tone measurements, the amplitudes of the input tones should be small enough so that gain compression can be neglected.) Frequencies: Set one at 50.01 MHz and the other to 49.99 MHz.
5. Using the combiner to drive the amplifier, record the output power of the components given by the VSA at the frequencies: 49.97 MHz, 49.99 MHz, 50.01 MHz, 50.03 MHz as the drive power from the signal generators is decreased in 1 dB steps. Take as many points as possible. Make sure that you have several sets of points at drive levels where gain compression can be neglected. It may be convenient to use the marker search function to move the marker from peak to peak when making these measurements. Try: [**Marker Search**][next peak left/right].
6. Remove the amplifier and feed the output of the combiner directly to the SA to find P_{in} at each of the drive levels that you used in step 5.
7. Using your power measurements, find the $P_I^{(i)}$ and $P_I^{(o)}$ using linear interpolation and extrapolation.

3.2.4 Noise Figure Measurements

3.2.4.1 Agilent N8973A Noise Figure Analyzer

The Agilent N8973A Noise Figure Analyzer greatly simplifies noise measurements of 2-port devices. Accurate noise figure, noise temperature, and power gain can be measured. Many measurement errors have been removed by using a precision noise source and a simple, automatic calibration procedure.

3.2.4.2 Noise Figure Measurement with the HP 8973A

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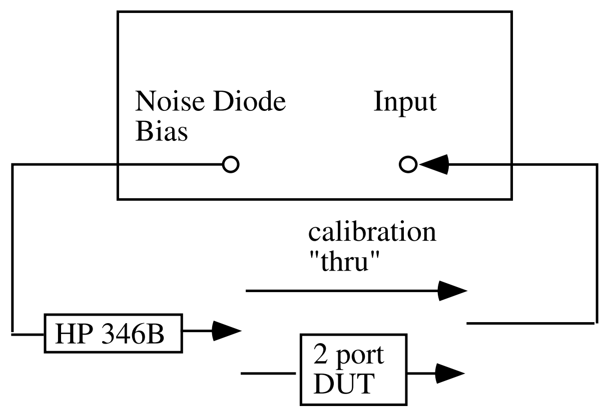

Figure 3.1: Noise Figure Analyzer setup

1. Connect the equipment as in Figure 3.1 for calibration. A “thru” connection should be used between the HP346B Noise Diode and the 8973A input. Use the shortest possible connection, which will be an N-type male-to-male adapter (or “barrel” adapter). The calibration procedure measures and stores the noise figure of the 8973A at each frequency. The stored values are used to subtract the noise contribution of the 8973A from measurements taken with the DUT in place.

2. Specify START/STOP frequencies and number of measurement points using the [Frequency/Points] menu. Set the bandwidth of the 8973A using the [Averaging/Bandwidth][Bandwidth] menu. The bandwidth defaults to 4 MHz. This is the noise bandwidth of the receiver in the 8973A. The measured noise figure and gain are effectively averaged over this bandwidth. If the characteristics of the DUT change appreciably over 4 MHz, then choose a smaller bandwidth. In general, you should choose the largest bandwidth over which the DUT’s characteristics can be assumed to be essentially constant.

3. Press CALIBRATE. The 8973A will proceed to measure its own noise characteristics.

4. After calibration is completed the display should show 0 dB for gain and noise figure, corresponding to the removal of the instrument’s own gain and noise from further measurements. You should check your calibration by measuring G and NF for an attenuator. Replace the thru connection with an attenuator and verify that -G and NF are equal to the attenuation in dB.

5. Insert DUT between noise source and 8973A input. Gain and NF at specified frequencies can be read directly using the markers. Note that any stray signals that are picked up by your

DUT will show up as "spikes" in the measured NF. Since your amplifier is not shielded in a metal box, you will probably see NF spikes within the FM broadcast band and possibly near 158 MHz where strong local signals are present. Take your readings at frequencies well away from any such spikes.

3.2.4.3 HP 346B Noise Source

The HP346B Noise Source is designed to have an impedance of approximately 50 Ω. The schematic in Figure 3.2 suggests that it is actually about 56 Ω when the diode is "off" — at least at low frequencies. When the noise diode is off (unbiased), the effective noise temperature of the source is 290K (room temperature). When the noise diode is on, the effective noise temperature is approximately 10,000K.

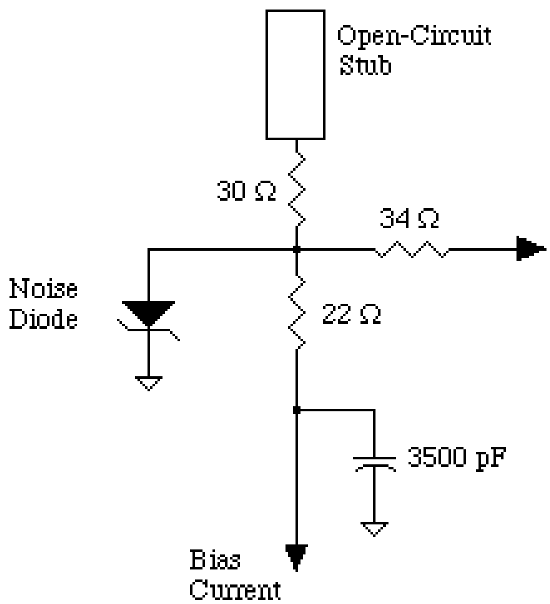

Figure 3.2: HP 346 noise source schematic