SNA … Measuring a Wideband Amplifier

K1TRB 5/6/17

Paul Kiciak, N2PK, created a couple wideband amplifiers to supplement his VNA design. I left out the built-in attenuators to obtain a couple very nice wideband buffers. The one tested here is the 12db amplifier described in his notes without the input and output attenuators.

http://n2pk.com/VNA/n2pk_vna_pt_2_ver_b2.pdf Page 27.

There are four ways in which Yana can be connected to the amplifier:

1. (Forward: |s21|) Generator -> amplifier input, amplifier output -> Detector.

2. (Reverse: |s12|) Generator -> amplifier output, amplifier input -> Detector.

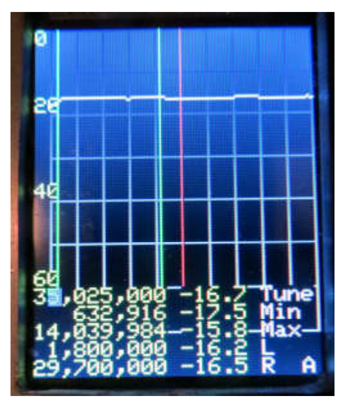
3. (Input Reflection: |s11|) Bridge -> amplifier input, amplifier output -> load.

4. (Output Reflection: |s22|) Bridge -> amplifier output, amplifier input -> load.

Each of these measurements gives useful information about the amplifier. Look at each of these connections in order. The prototype of Yana is shown.

In the following I've been sloppy with precise definitions in order to emphasize concepts. If you would like to know the precise meanings, they are spelled out on Wikipedia pages: https://en.wikipedia.org/wiki/Scattering_parameters

1. Forward Connection

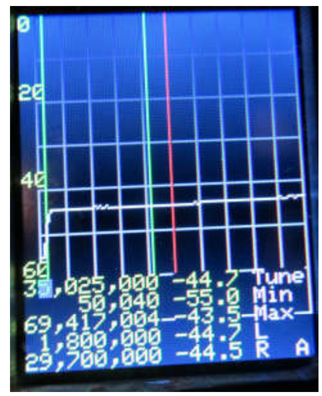


In this connection, the gain and bandwidth of the amplifier are measured. The picture at the right shows the connections. The output of the amplifier may overdrive the Detector so that attenuation is necessary. Further, the Generator may overdrive the amplifier so that attenuation should be placed at the input to the amplifier. The maximum input to the detector should be about 10dbm. (Actually, the detector remains accurate up to about 12dbm before accuracy suffers.) The output of the generator goes up to about 1dbm. A 12db amplifier would raise this to 13db, unacceptable for the Yana detector. Attenuation is needed.

The calibration attenuator is -28.5db so that it will serve for amplifiers of gain up to 28.5db. A step attenuator would be easier to use since it could be adjusted so Yana registers 0db gain. Then the gain of the amplifier is equal to the attenuator setting.

Yana is set to sweep the full range with markers set for the high frequency bands. With the -28.5db attenuator, the gain is recorded from Yana and 28.5db is added to the result to obtain the amplifier gain. The screen on the previous page shows the gain is about 12db = -16.5 + 28.5. As I said, this is a well-designed amplifier giving the gain for which it was designed. The graph shows that the gain is constant over the range of Yana. In fact, I've used this amplifier on 2 meters. The 12db gain value is usually called |s21| expressed in db, or the **scalar logarithmic gain**. It is the useful gain when both the input and output are matched to 50 ohms. This makes sense because the output of the Generator is known to Yana and the input to the Detector is what is measured by Yana.

2. Reverse Connection

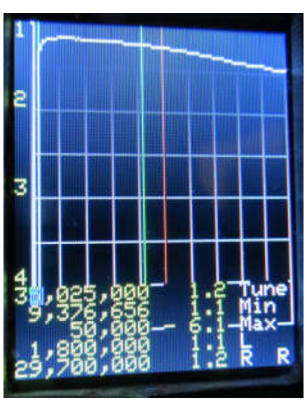


The input and output can be reversed so that the Generator is fed to the output of the amplifier and the Detector is connected to the input of the amplifier. The attenuator is left on the amplifier output. The picture above and to the right shows the connections.

The graph at the right shows the result. Now the gain is -16db = -44.5 + 28.5. As we would expect, there is a loss between the output and the input. This figure is often expressed as |s12| in db, or the **reverse gain**. It is a measure of the isolation between the input and the output.

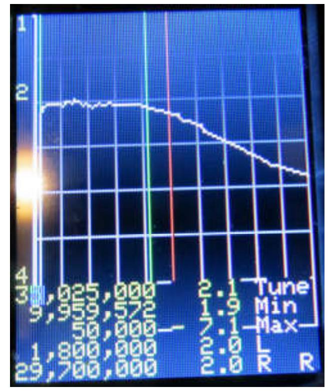
3. Input Reflection

When connecting the amplifier to various devices, it is good to know how closely matched the input and output are to 50 ohms. These quantities can be measured using the bridge on Yana. The hookup of the bridge to the amplifier **input** is show at the right. A 50 ohm load is connected to the amplifier output.



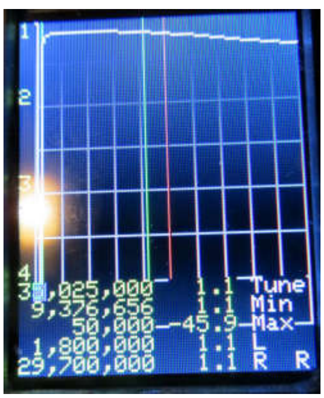
With Yana now measuring SWR, the screen at the left is shown. If the amplifier output exactly matched 50 ohms, the trace would be horizontal at 1. The bridge is dysfunctional at 50 KHz so that reading is probably wrong. At higher frequencies, the SWR rises to about 1.2, which is still very good. The SWR can be expressed in different units as **return loss** which is a measure of how much the Generator signal is NOT reflected back to the Generator (i.e. a big return loss is a good thing because it means very little is reflected back, so that match is good).

Looking above again, the reverse gain gives some idea of the isolation of the output from the input. When the two are not totally isolated, a change in the impedance of the output load will affect the input impedance of the amplifier. This can be measured by changing the load on the output. The picture at the right shows the SWR when the output load is changed to 200 ohms. A load of 200 ohms creates an SWR of 4. If there were no isolation, the input impedance to the amplifier would also have SWR 4 (i.e. be 200 ohms). Isolation is good but not great, the input impedance rises to an SWR of 2 or about 100 ohms. The input reflection is often denoted |s11| and called the magnitude of the **reflection coefficient**. When translated to db it is called **return loss**.

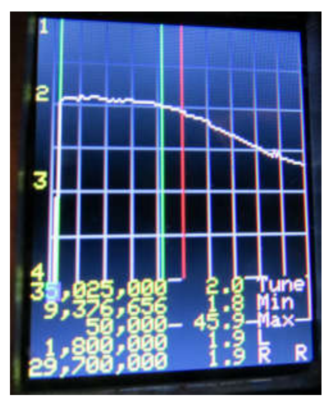


4. Output Reflection

Reflection may also be measured at the output of the amplifier. This time the bridge is connected to the output of the amplifier and a load is connected to the input as shown at the right.



The result is shown at the left. The output SWR is again close to 1. The return loss is large. But what about changes in the source (input) impedance? The result at the left is obtained with a 50 ohm load on the input. A 200 ohm load gives the result at the right. Again, the isolation is good but not great. It appears to be slightly better than reflection at the input.



5. Conclusions

When designing an amplifier, it is good to have both the input and output impedance be about 50 ohms so that power is moved through the system predictably. These measurements can be used to tweak input and output transformers and resistors to get gain and match correct at the frequencies of interest.