Instructions for Carrying Out "Generic" Spectral Analysis Measurements with the HP-3562A Dynamic Signal Analyzer

Last Updated: 01/16/2014 12:50 hr {SME}

The following instructions are for carrying out "generic" spectral analysis measurements using the HP-3562A Dynamic Signal Analyzer (DSA). For example, if you are interested in measuring the (frequency-domain) complex specific longitudinal input impedance $\tilde{Z}_a^{\parallel}(r,f)=\tilde{p}(r,f)/\tilde{u}_{\parallel}(r,f)$ of a brass/wind instrument (or *e.g.* $\tilde{Z}_a^{\parallel}(r,f)$ at a specific point *r* in an arbitrary complex sound field), the experimental setup needed for this might look similar to that shown in the figure below:

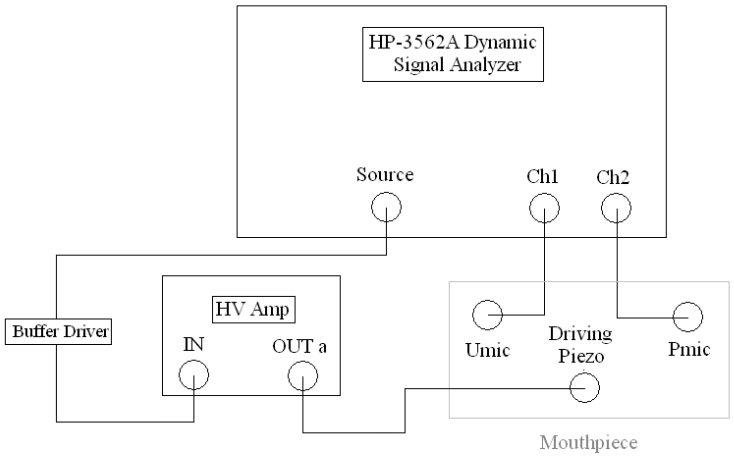


Figure 1. Experimental setup for measuring the acoustic impedance of a complex sound field.

If you were instead interested in measuring the complex electrical impedance $\tilde{Z}_e(f)=\tilde{V}(f)/\tilde{I}(f)$ of an electric guitar pickup, or *e.g.* that of a loudspeaker, the experimental setup needed for this might look similar to that shown in the figure below:

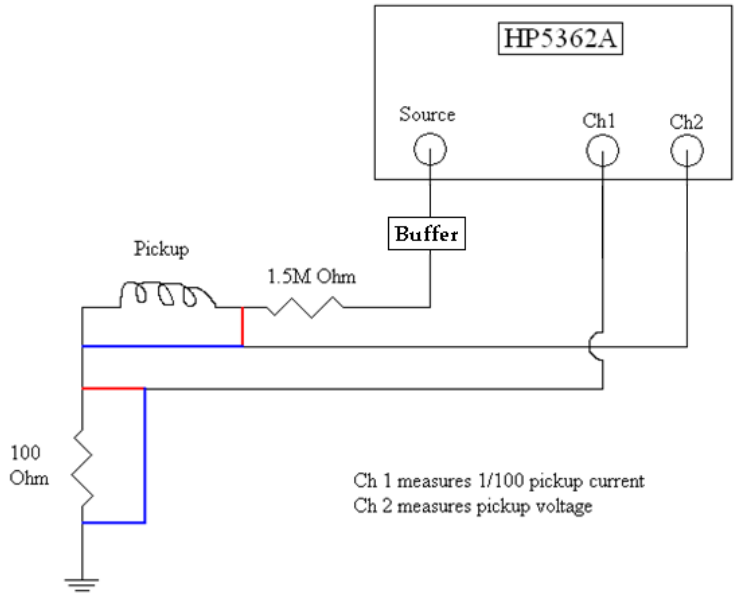


Figure 2. Experimental setup for measuring the impedance of an electric guitar pickup.

Brief Instructions: Please follow carefully – don't hesitate to ask a POM TA for help!!!

0.) Without powering any equipment up (yet), assemble, setup & connect/wire up all necessary equipment that you will need to carry out your experiment. When done with this step, ask a POM TA to explicitly check your work – we *must* avoid damaging equipment at all costs!

1.) Turn on the AC power to HP3652A DSA, any needed LVDC power supplies, amplifiers, etc. Note that it takes ~ 1 minute for the DSA to fully boot up. Check LED indicators on power supplies, amplifiers to verify that they are working properly – if not, turn off & contact TA!

** Important Note: the red "over range" LEDs above the DSA Ch1/Ch2 inputs should ***never*** be ***steadily*** lit! **

2.) Enter Swept-Sine Mode (for DSA internal source):
a. MEASUREMENT: press: **MEAS MODE**
b. CRT button: press: **SWEPT SINE**
c. CRT button: press: **LOG SWEEP** (*n.b.* is default, so don't need to explicitly do this)

3.) Define Measurement Type:
a. MEASUREMENT: press: **SELECT MEAS**
b. CRT button: press: **FREQ RESP**

4.) Define (Log!) Frequency Range:
a. MEASUREMENT: press: **FREQ**
b. CRT button: press: **START FREQ**, use keypad to enter start frequency, *e.g.* **10**
c. CRT button: press correct units: *e.g.* **Hz**
d. CRT button: press: **STOP FREQ**, use keypad to enter stop frequency, *e.g.* **10**
e. CRT button: press correct units: *e.g.* **KHz**

** This example gives a frequency sweep range of **10Hz-10KHz**; It will give a total of **801** samples in equal steps in log(frequency) **

Frequently, for some reason (not currently understood), entering the start/stop frequencies seems to fail the first time. Thus, after completing step 4, we strongly recommend that you:

f. CONTROL: press the yellow-orange START button
g. Explicitly check the start/stop frequencies on the CRT screen
h. CONTROL: press the yellow-orange PAUSE button
i. If the start/stop frequencies are incorrect, repeat Step 4 above, including steps f-i.

5.) Define Averaging (per frequency point):
a. MEASUREMENT: press: **AVG**
b. CRT button: press: **FIXED INTGRT** (*n.b.* is default, so don't need to explicitly do this)
c. CRT button: press: **NUMBER AVGS,** use keypad to type # of averages, *e.g.* **5-10** avgs)
d. CRT button: press: **ENTER**

6.) Define Amplitude of DSA Internal Source:
a. MEASUREMENT: press: **SOURCE**
b. CRT button: press: **SOURCE LEVEL,** use keypad to enter source level, *e.g.* **100**
c. CRT button: press correct units: *e.g.* **mVrms**

** In this example, we set the amplitude of the internal source to **100 mV rms**.
n.b. it is very important not to mis-enter the source amplitude – it could damage equipment!
Hence, please be very careful when doing this! **

7.) <u>Carry Out the Frequency Scan</u>:
a. CONTROL: press the yellow-orange START button
b. Wait for the frequency scan to complete – typically takes ~ several-10 minutes.

8.) <u>When Frequency Scan Has Completed, Can Look At (and/or Read-Out) Spectral Data</u>:
a. DISPLAY: **SELECT DATA:** press: **MEAS DISP** button
b. On RHS of CRT, can select/view displays of:

{*n.b*. Refer to Physics 406 Lect. Notes 13 Part 2 *p*. 17-23 on Spectral Analysis Techniques}

- **FREQ RESP:** $\tilde{G}_{y\star x}(f)/\tilde{G}_{x\star x}(f)$ **{$\propto$ complex $\tilde{Z}_a(f), \tilde{Z}_e(f)$!!}**
- **COHER:** $\left|\tilde{\gamma}_{x\star y}(f)\right|^2 \equiv \left[\tilde{G}_{y\star x}(f)\tilde{G}_{x\star y}(f)\right]/\left[\tilde{G}_{x\star x}(f)\tilde{G}_{y\star y}(f)\right]$ **{purely real quantity}**
- **POWER SPEC1:** $\tilde{G}_{x\star x}(f) = \tilde{x}^*(f)\cdot\tilde{x}(f) = \left|\tilde{x}(f)\right|^2$ **{Ch. 1 (*u* or *I*), purely real quantity}**
- **POWER SPEC2:** $\tilde{G}_{y\star y}(f) = \tilde{y}^*(f)\cdot\tilde{y}(f) = \left|\tilde{y}(f)\right|^2$ **{Ch. 2 (*p* or *V*), purely real quantity}**
- **CROSS SPEC:** $\tilde{G}_{y\star x}(f) = \tilde{y}^*(f)\cdot\tilde{x}(f) = \tilde{x}(f)\cdot\tilde{y}^*(f)$ **{$\propto$ complex $\tilde{I}_a(f), \tilde{P}_e(f)$!!}**

<u>Define Y-Axis Auto-Scale</u>: {Optional, makes viewing plots on CRT easier}
a. DISPLAY: DEFINE TRACE: press: **SCALE** button
b. CRT Button: press: **Y AUTO SCALE**

<u>Enable X or Y Marker(s)</u>: {Optional, *e.g*. if want to know specific (X,Y) values of data}
a. MARKERS: press: **X** or **Y** button
b. MARKERS: turn knob to set/adjust/move X or Y marker position
c. Look at/observe corresponding (X,Y) data at top LHS of CRT screen

The data associated with each of the above plots can readout via GPIB into a PC using the NI LabView program **P406_LV_DAQ\NEW_HP3562A\HP3562A_DSA.vi** program. Ask the POM TA to show you how to do this. On the GUI for **HP3562A_DSA.vi**, you will need to set the proper path to write out a user-specified *.txt data file to a sub-folder in the PC's **P406_LV_DAQ\NEW_HP3562A\DATA** area.

<u>Important Notes</u>:

a.) If the HP3562A is in the process of **calibrating** itself (notice shows up at the bottom of DSA CRT), you ***<u>must</u>*** wait until the calibration has completed to carry out a GPIB readout of the DSA. If this happens during a calibration, it locks up the DAQ .and. the DSA! Contact a POM TA if this happens – we will have to cold-reboot both the PC .and. the DSA!

b.) You ***<u>must</u>*** read out all of the above **purely real** quantities with the toggle switch on the **HP3562A_DSA.vi** GUI in the **Auto-Correlation** position; you ***<u>must</u>*** read out all of the above **complex quantities** with the toggle switch on the **HP3562A_DSA.vi** GUI in the **Cross-Correlation** position. The DAQ readout of **purely real** *vs*. **complex** quantities is ***<u>not</u>*** the same!

c.) Note also that the *.txt data format for **purely real quantities** is **801** rows of **2** columns (frequency and *e.g*. magnitude-squared $\tilde{G}_{x\star x}(f) = \tilde{x}^*(f)\cdot\tilde{x}(f) = \left|\tilde{x}(f)\right|^2$) ; the *.txt data format for **complex quantities** is **801** rows of **3** columns (frequency and *e.g*. $\mathrm{Re}\left\{\tilde{G}_{y\star x}(f)\right\}$, $\mathrm{Im}\left\{\tilde{G}_{y\star x}(f)\right\}$).

9.) <u>You can also look at (and/or read-out) *additional* spectral data</u>:

<u>For each selected plot/trace in 8.) above, you can also look at</u>:
a. DISPLAY: **DEFINE TRACE:** press: **COORD** button
b. On the RHS of the CRT, can select/view displays of:

- **Mag (dB) (Magnitude, expressed in dB)**
- **Mag (dBm) (Magnitude, expressed in dBm {referenced to 1 mW})**
- **Mag (LOG) (Magnitude, plotted on $\log_{10}$ scale)**
- **Mag (LIN) (Magnitude, plotted on linear scale)**
- **Phase (complex quantities, only – *n.b.* also works for Ch1 (X) and/or Ch2 (Y))**
- **Real (real part of complex quantity)**
- **Imag (imaginary part of complex quantity)**
- **Nyquist (Nyquist Plot = Imag *vs.* Real plot – complex quantities only)**
- **Nichol (Nichol Plot = Mag (dB) *vs.* Phase plot – complex quantities only)**

<u>Offline Data Analysis</u>:

There exist MATLAB-based *.m file scripts located in the POM Backup Server Area (Access these via use of the shortcut "New P406POM Backup" on the desktop of POM PC):

\Common\MATLAB_Analyses\HP3562A_Spectral_Analyses

Copy the relevant MATLAB *.m script files to a subfolder the Local MATLAB Work folder on the PC – e.g. in a sub-folder that <u>*you*</u> create on the local PC for your <u>*own*</u> analysis:

C:\Program Files\MATLAB\R2012a\work\HP3562A_Spectral_Analyses\My_Analysis_Subfolder

Edit/modify these MATLAB script(s) for your own individual/specific needs. Don't hesitate to ask a POM TA for help in doing this! The MATLAB *.m scripts will a.) absolutely calibrate your spectral data data and b.) make plots of your absolutely-calibrated spectral quantities. You can save all of the plots (*.fig, *.pdf and *.png formats) using the corresponding Matlab *Save_Pix.m scripts – produces a Pix folder containing these plots. Rename this Pix folder to something meaningful/specific to your data analysis.

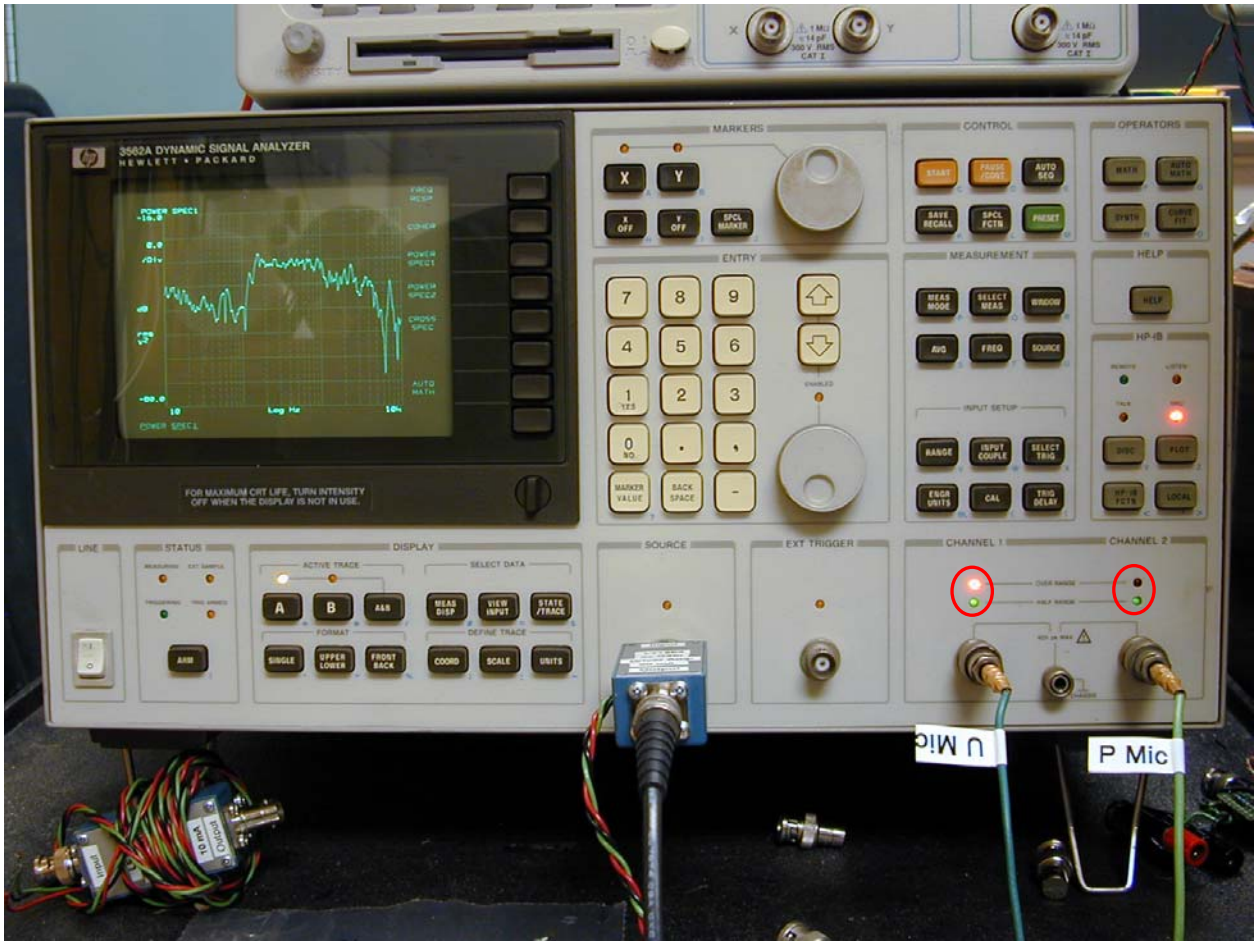
When you have completed analysis of your data on the local PC, you <u>*must*</u> copy the contents of your local MATLAB analysis My_Analysis_Subfolder to its corresponding location in the POM Backup Server (Note that <u>*nothing*</u> is backed up on any of the PC's in the POM lab!!!!):

\Common\MATLAB_Analyses\HP3562A_Spectral_Analyses\My_Analysis_Subfolder

Detailed Instructions: Please follow carefully – don't hesitate to ask a POM TA for help!!!

0.) Without powering any equipment up (yet), assemble, setup & connect/wire up all necessary equipment that you will need to carry out your experiment. When done with this step, ask a POM TA to explicitly check your work – we *must* avoid damaging equipment at all costs!

1.) Turn on the AC power to HP3652A DSA, any needed LVDC power supplies, amplifiers, etc. Note that it takes ~ 1 minute for the DSA to fully boot up. Check LED indicators on power supplies, amplifiers to verify that they are working properly – if not, turn off & contact TA!



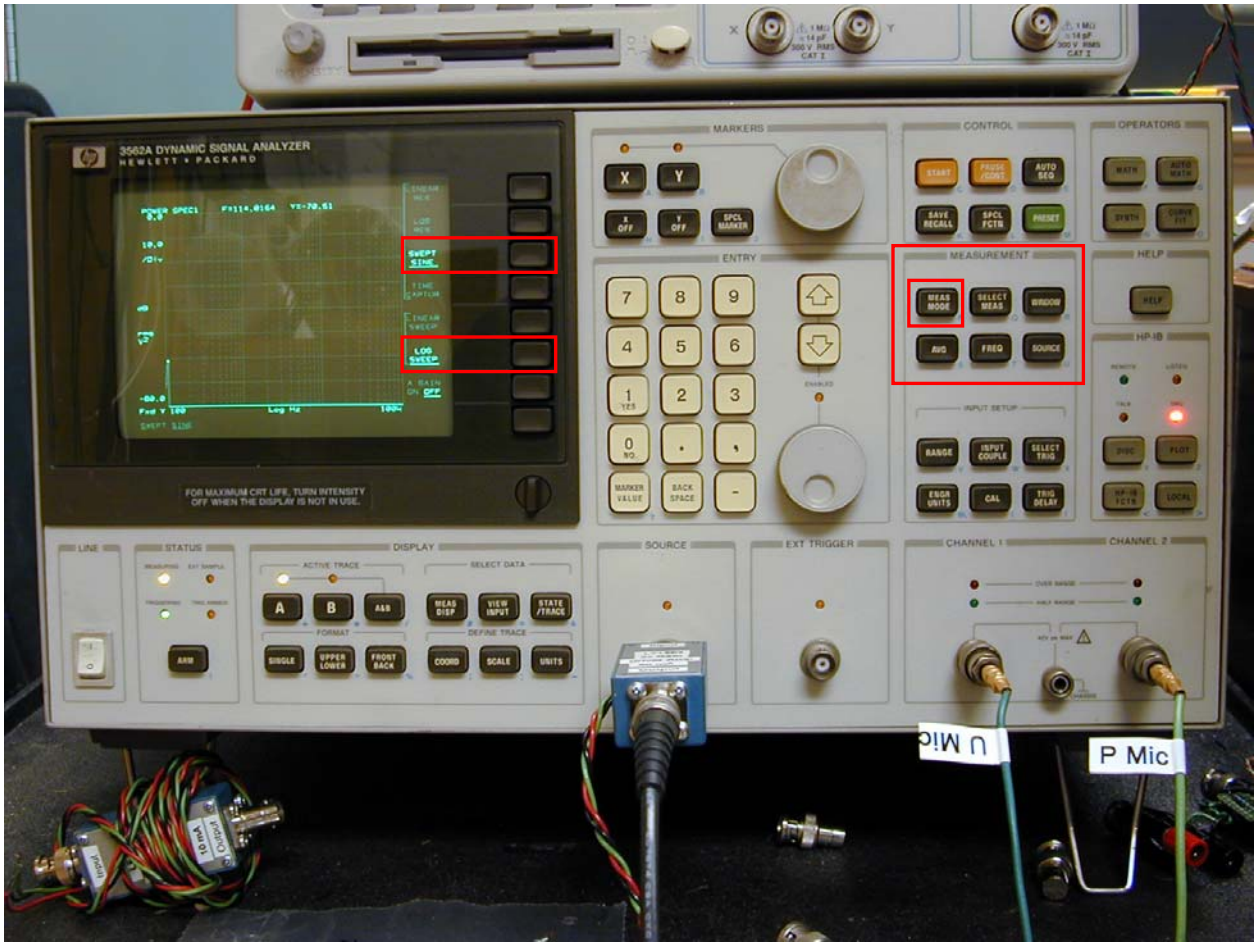
** Important Note: the **red** "over range" LEDs above the DSA Ch1/Ch2 inputs should ***never*** be ***steadily*** lit! Disconnect input(s) immediately and contact POM TA if this happens!!!! **

2.) <u>Enter Swept-Sine Mode (for DSA internal source)</u>:

a. MEASUREMENT: press: **MEAS MODE**

b. CRT button: press: **SWEPT SINE**

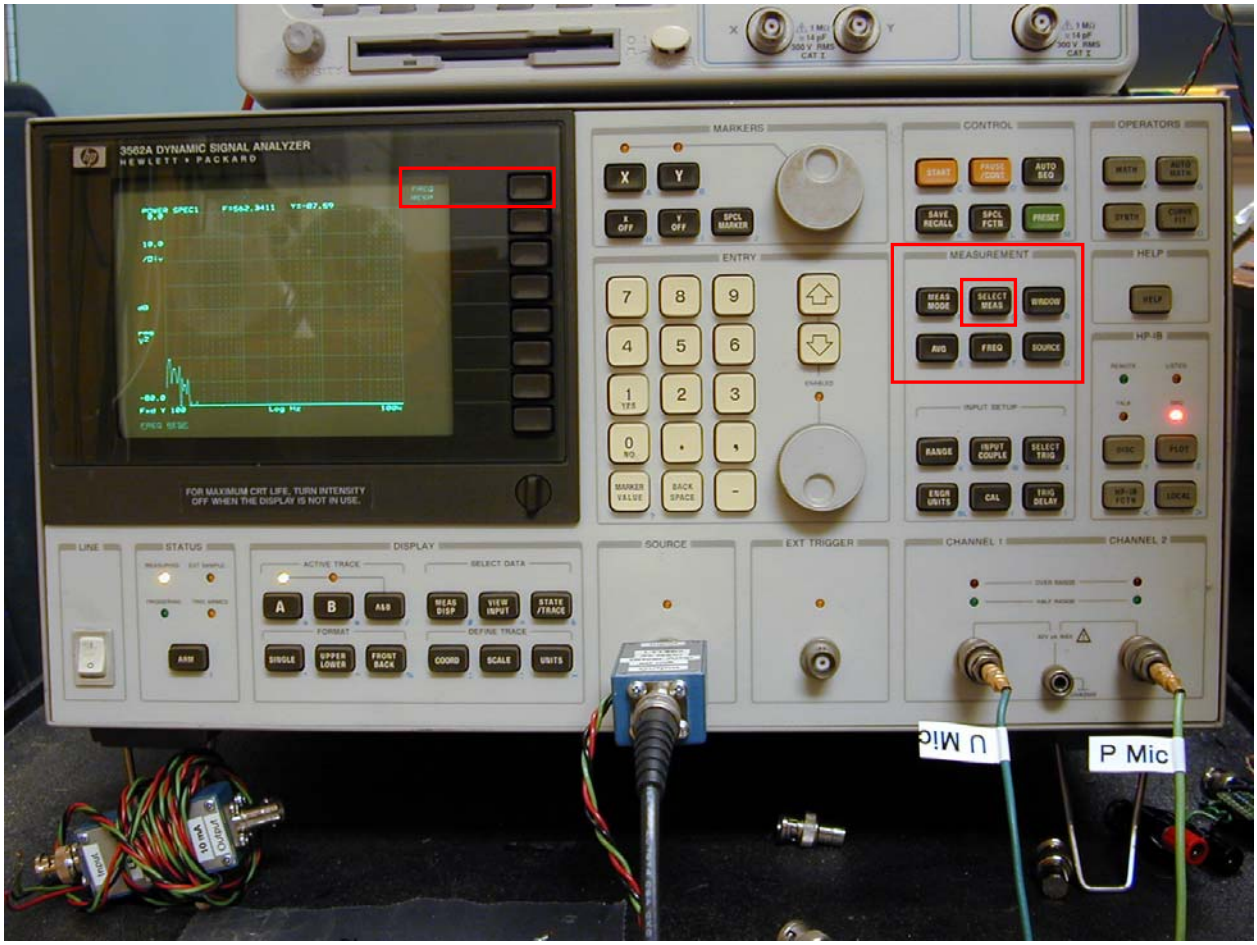
c. CRT button: press: **LOG SWEEP** (*n.b.* is default, so don't need to explicitly do this)



3.) <u>Define Measurement Type</u>:

a. MEASUREMENT: press: **SELECT MEAS**

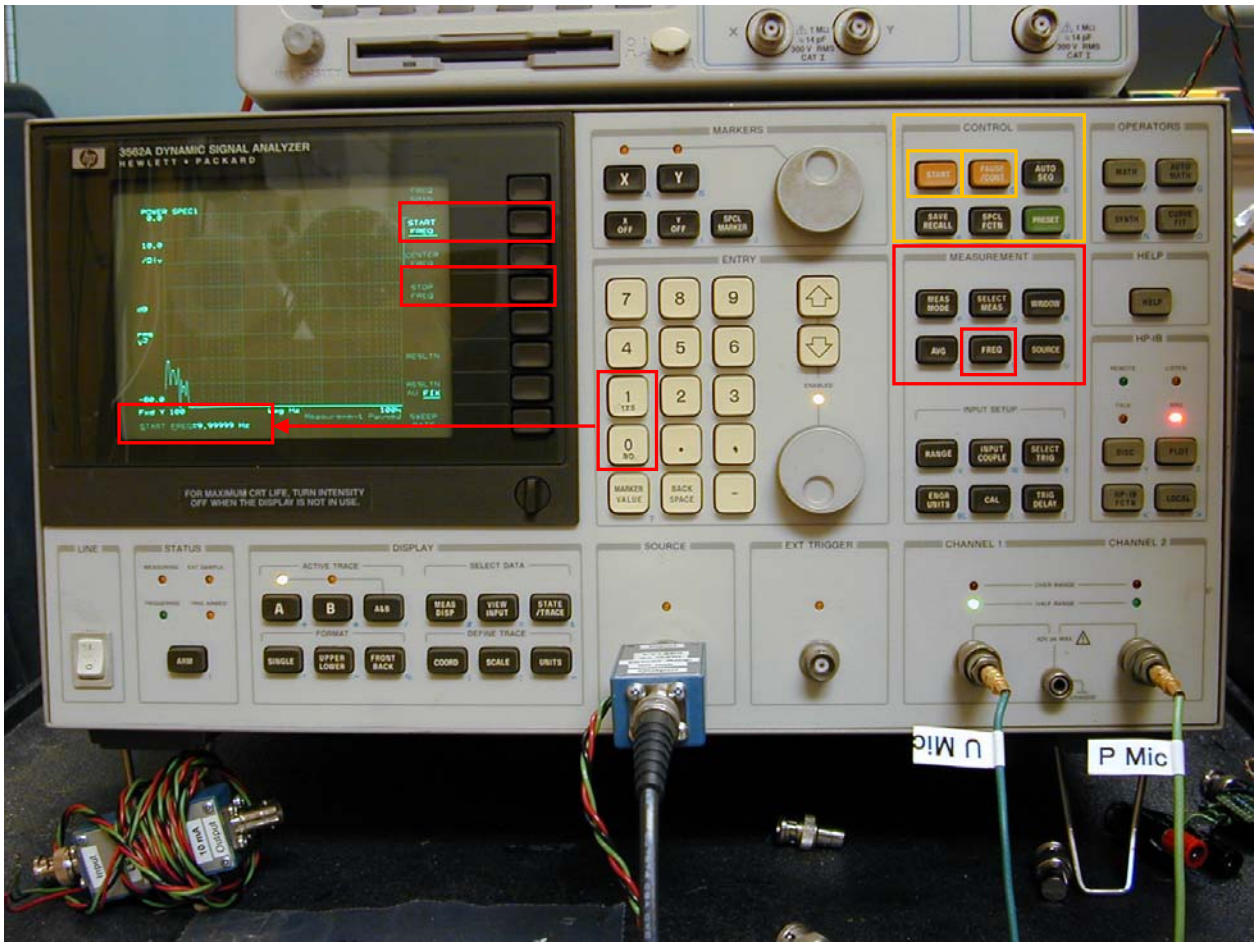
b. CRT button: press: **FREQ RESP** (*n.b.* is default, so don't need to explicitly do this)



4.) <u>Define (Log!) Frequency Range</u>:

a. MEASUREMENT: press: **FREQ**
b. CRT button: press: **START FREQ**, use keypad to enter start frequency, *e.g.* **10**
c. CRT button: press correct units: *e.g.* **Hz**
d. CRT button: press: **STOP FREQ**, use keypad to enter the stop frequency, *e.g.* **10**
e. CRT button: press correct units: *e.g.* **KHz**

** This example gives a frequency sweep range of **10Hz-10KHz**; It will give a total of **801** samples in **equal** steps in **log(frequency)** **



Frequently, for some reason (not currently understood), entering the start/stop frequencies seems to fail the first time. Thus, after completing step 4, we strongly recommend that you:

f. CONTROL: press the yellow-orange START button
g. Explicitly check the start/stop frequencies on the CRT screen
h. CONTROL: press the yellow-orange PAUSE button
i. If the start/stop frequencies <u>*are*</u> incorrect, then repeat Step 4 above, including steps f-i.

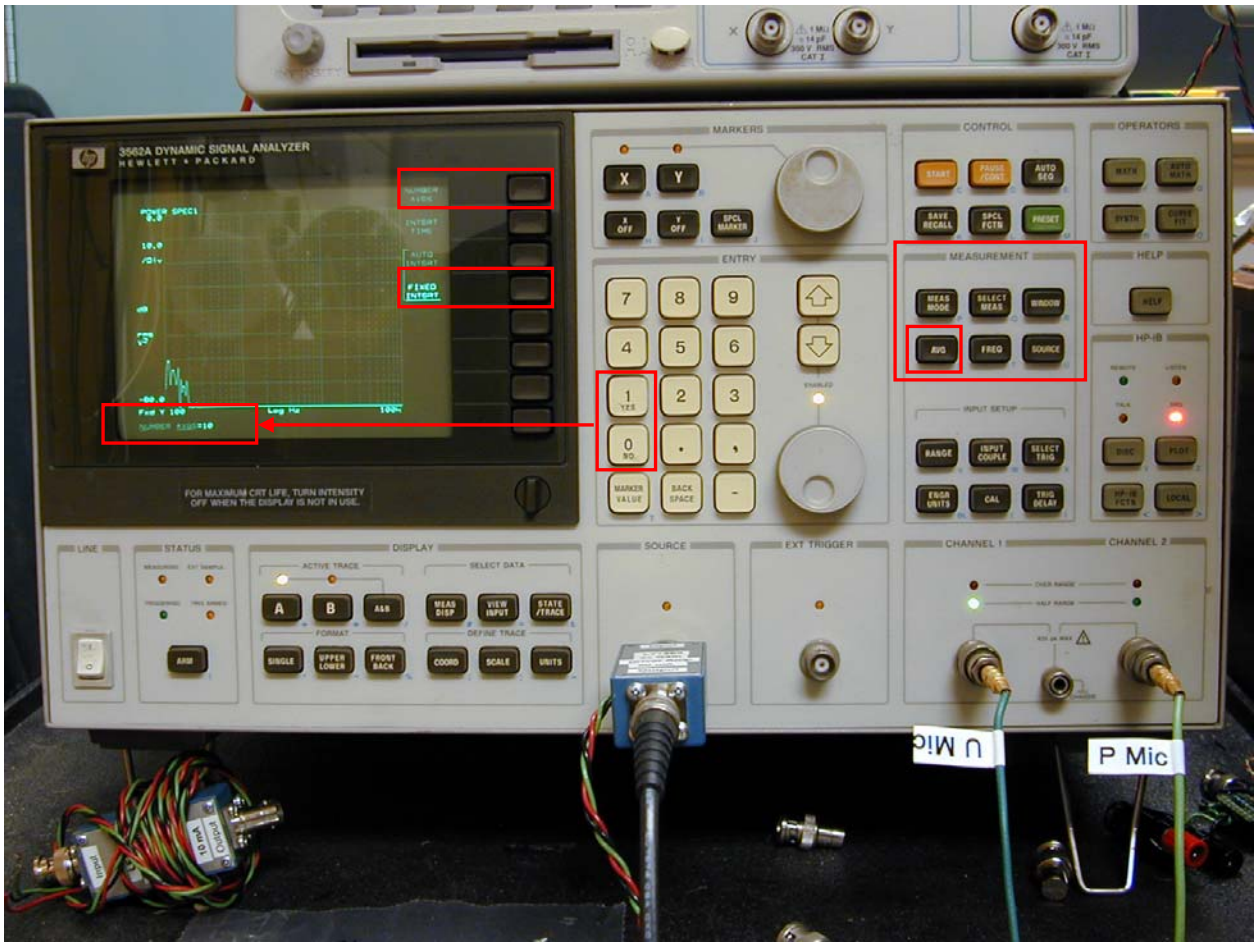
5.) <u>Define Averaging (per frequency point)</u>:

a. MEASUREMENT: press: **AVG**

b. CRT button: press: **FIXED INTGRT** (*n.b.* is default, so don't need to explicitly do this)

c. CRT button: press: **NUMBER AVGS,** use keypad to type # of averages, *e.g.* **5-10** avgs)

d. CRT button: press: **ENTER**



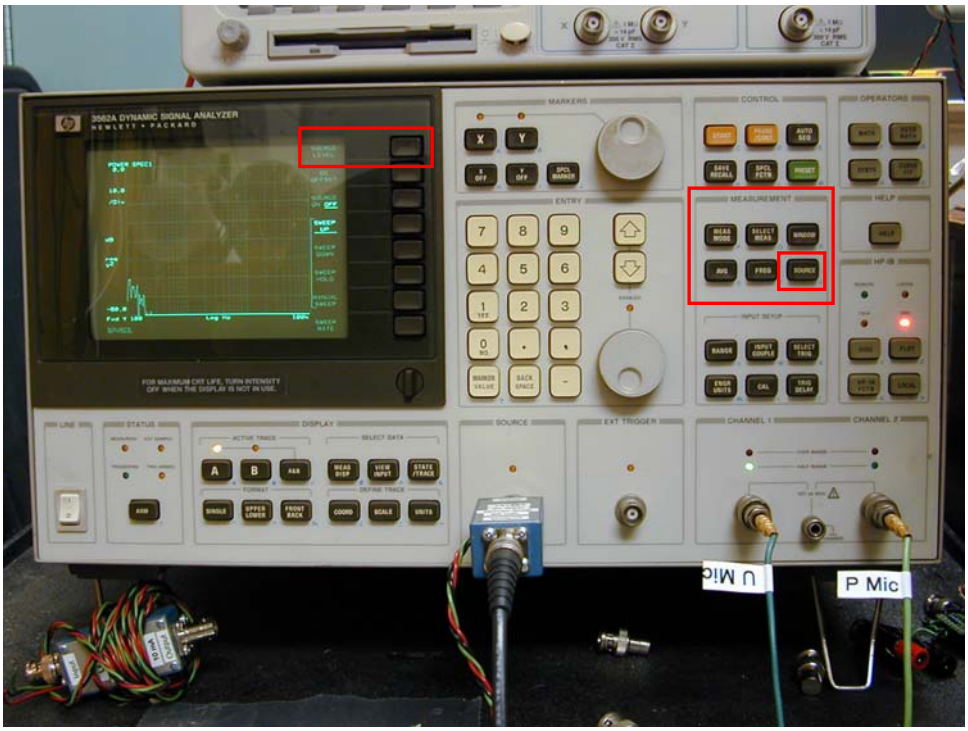
6.) <u>Define Amplitude of DSA Internal Source</u>:

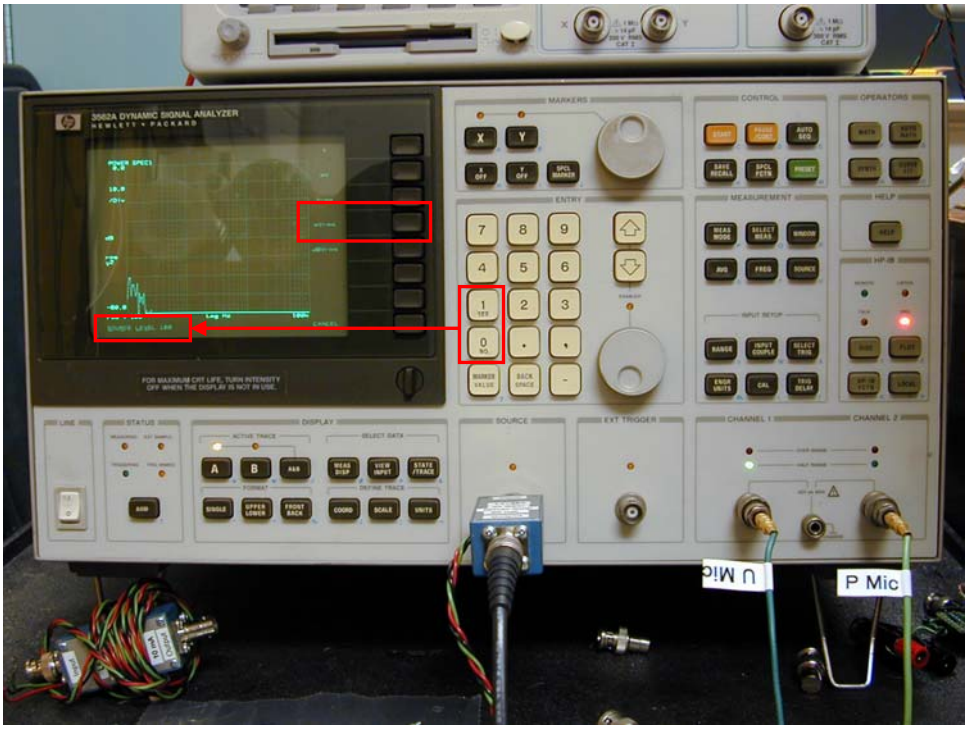
a. MEASUREMENT: press: **SOURCE**

b. CRT button: press: **SOURCE LEVEL,** use keypad to enter source level, *e.g.* **100**

c. CRT button: press correct units: *e.g.* **mVrms**

** In this example, we set the amplitude of the internal source to **100 mV rms**.
n.b. it is very important not to mis-enter the source amplitude – it could damage equipment!
Hence, please be very careful when doing this! **

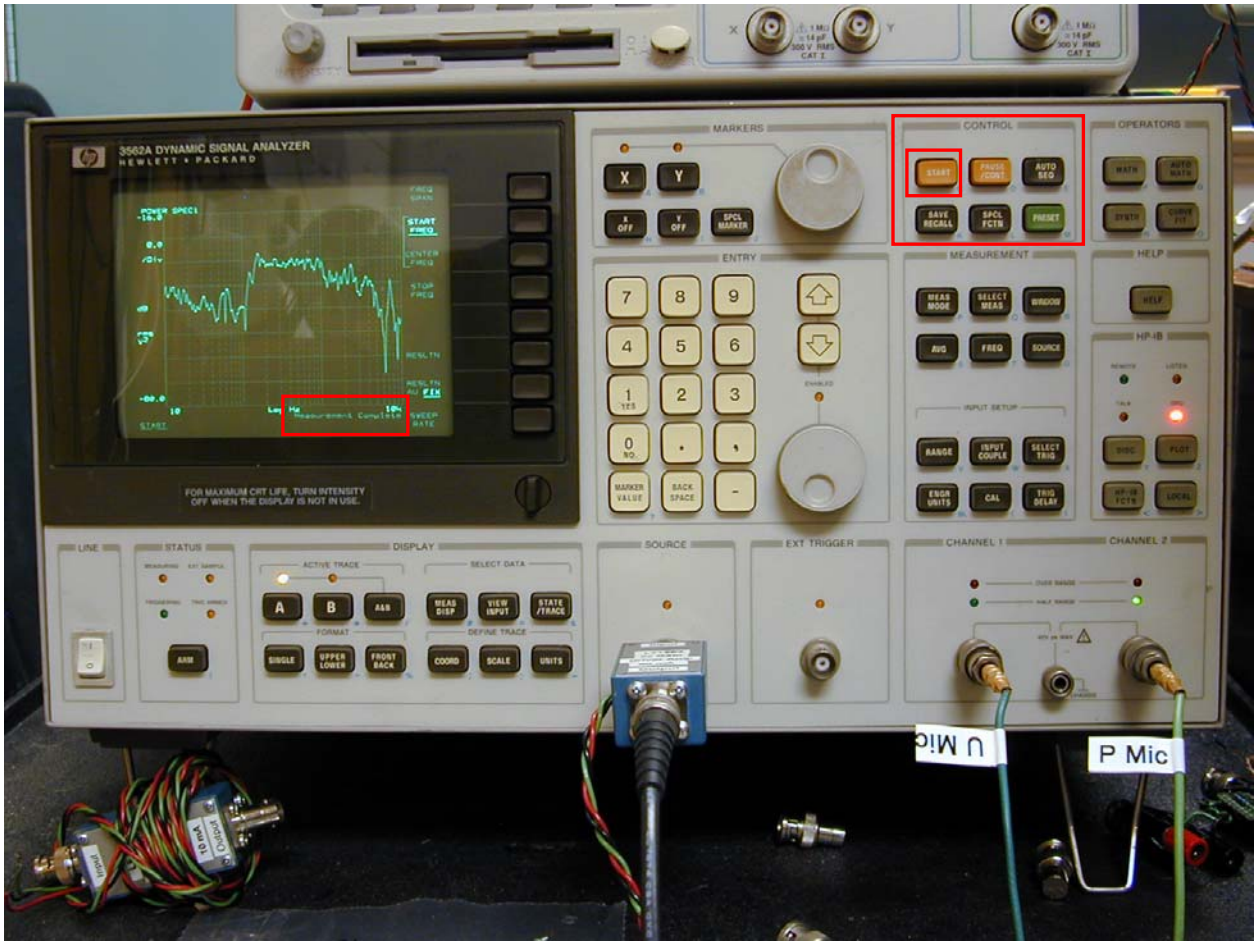




7.) <u>Carry Out the Frequency Scan</u>:

a. CONTROL: press the yellow-orange START button

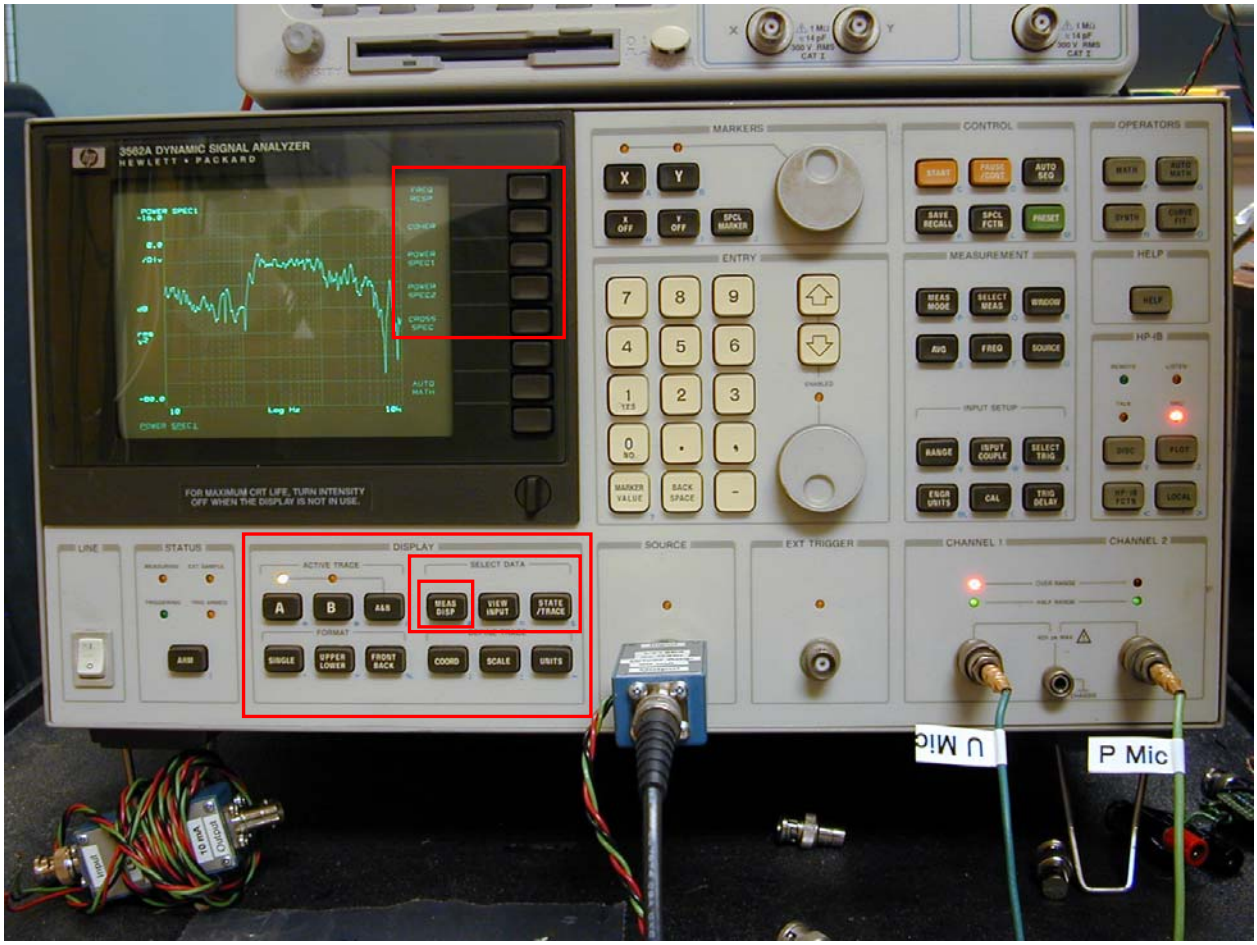
b. Wait for the frequency scan to complete – typically takes ~ several-10 minutes.



8.) <u>When Frequency Scan Has Completed, Can Look At (and/or Read-Out) Spectral Data</u>:
a. DISPLAY: **SELECT DATA:** press: **MEAS DISP** button
b. On RHS of CRT, can select/view displays of:

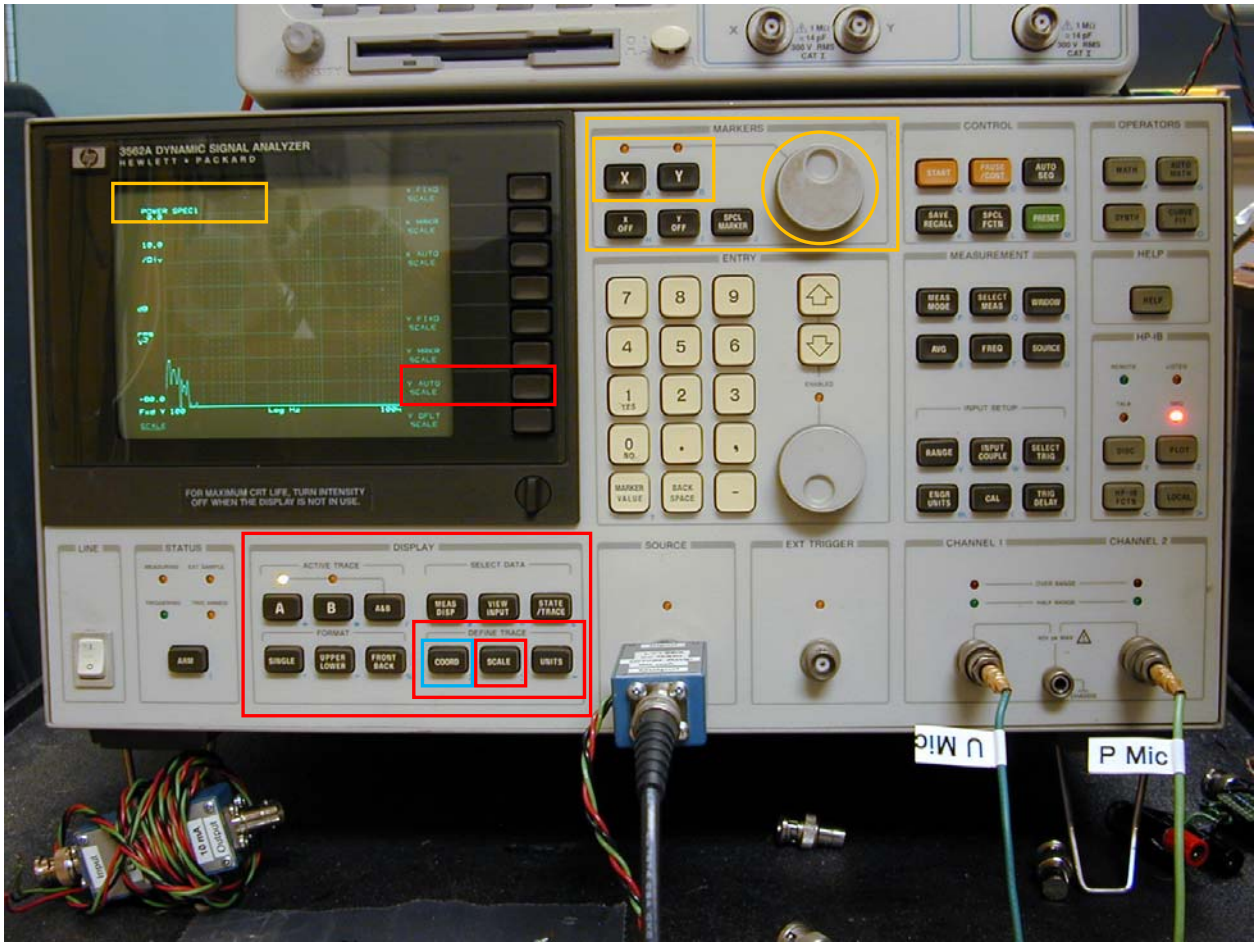
{*n.b.* Refer to Physics 406 Lect. Notes 13 Part 2 *p.* 17-23 on Spectral Analysis Techniques}

- **FREQ RESP:** $\tilde{G}_{y\star x}(f)/\tilde{G}_{x\star x}(f)$ **{ $\propto$ complex $\tilde{Z}_a(f), \tilde{Z}_e(f)$!!}**
- **COHER:** $\left|\tilde{\gamma}_{x\star y}(f)\right|^2 \equiv \left[\tilde{G}_{y\star x}(f)\tilde{G}_{x\star y}(f)\right]/\left[\tilde{G}_{x\star x}(f)\tilde{G}_{y\star y}(f)\right]$ **{purely real quantity}**
- **POWER SPEC1:** $\tilde{G}_{x\star x}(f) = \tilde{x}^*(f)\cdot\tilde{x}(f) = \left|\tilde{x}(f)\right|^2$ **{Ch. 1 (*u* or *I*), purely real quantity}**
- **POWER SPEC2:** $\tilde{G}_{y\star y}(f) = \tilde{y}^*(f)\cdot\tilde{y}(f) = \left|\tilde{y}(f)\right|^2$ **{Ch. 2 (*p* or *V*), purely real quantity}**
- **CROSS SPEC:** $\tilde{G}_{y\star x}(f) = \tilde{y}^*(f)\cdot\tilde{x}(f) = \tilde{x}(f)\cdot\tilde{y}^*(f)$ **{ $\propto$ complex $\tilde{I}_a(f), \tilde{P}_e(f)$!!}**



<u>Define Y-Axis Auto-Scale</u>: {Optional, makes viewing plots on the CRT easier}
a. DISPLAY: DEFINE TRACE: press: **SCALE** button
b. CRT Button: press: **Y AUTO SCALE**

<u>Enable X or Y Marker(s)</u>: {Optional, *e.g.* if want to know specific (X,Y) values of data}
a. MARKERS: press: **X** or **Y** button
b. MARKERS: turn knob to set/adjust/move X or Y marker position
c. Look at/observe corresponding (X,Y) data at top LHS of CRT screen



The data associated with each of the above plots can readout via GPIB into a PC using the NI LabView program **P406_LV_DAQ\NEW_HP3562A\HP3562A_DSA.vi** program. Ask the POM TA to show you how to do this. On the GUI for **HP3562A_DSA.vi**, you will need to set the proper path to write out a user-specified *.txt data file to a sub-folder in the PC's **P406_LV_DAQ\NEW_HP3562A\DATA** area.

Important Notes:

a.) If the HP3562A is in the process of **calibrating** itself (notice shows up at the bottom of DSA CRT), you ***must*** wait until the calibration has completed to carry out a GPIB readout of the DSA. If this happens during a calibration, it locks up the DAQ .and. the DSA! Contact a POM TA if this happens – we will have to cold-reboot both the PC .and. the DSA!

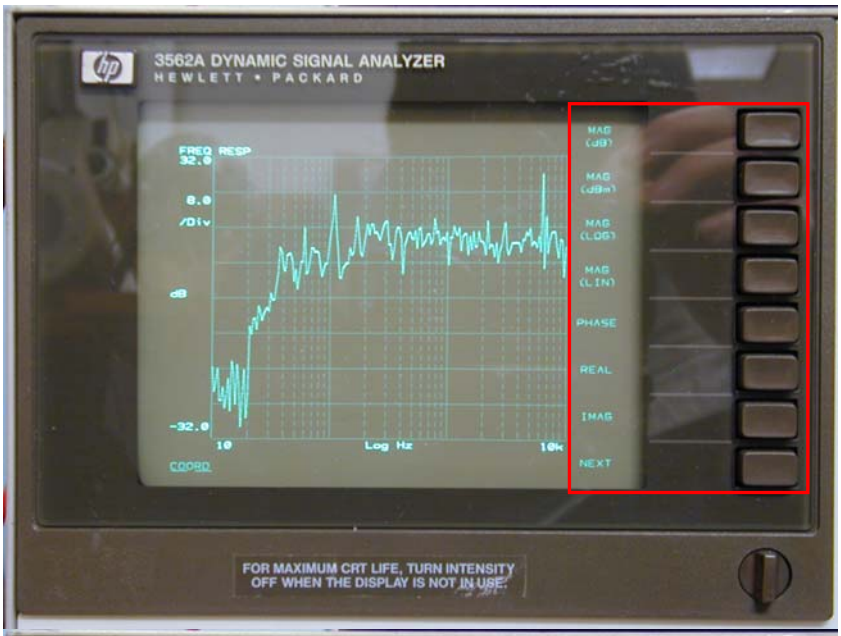
b.) You ***must*** read out all of the above **purely real** quantities with the toggle switch on the **HP3562A_DSA.vi** GUI in the **Auto-Correlation** position; you ***must*** read out all of the above **complex quantities** with the toggle switch on the **HP3562A_DSA.vi** GUI in the **Cross-Correlation** position. The DAQ readout of **purely real** *vs*. **complex** quantities is ***not*** the same!

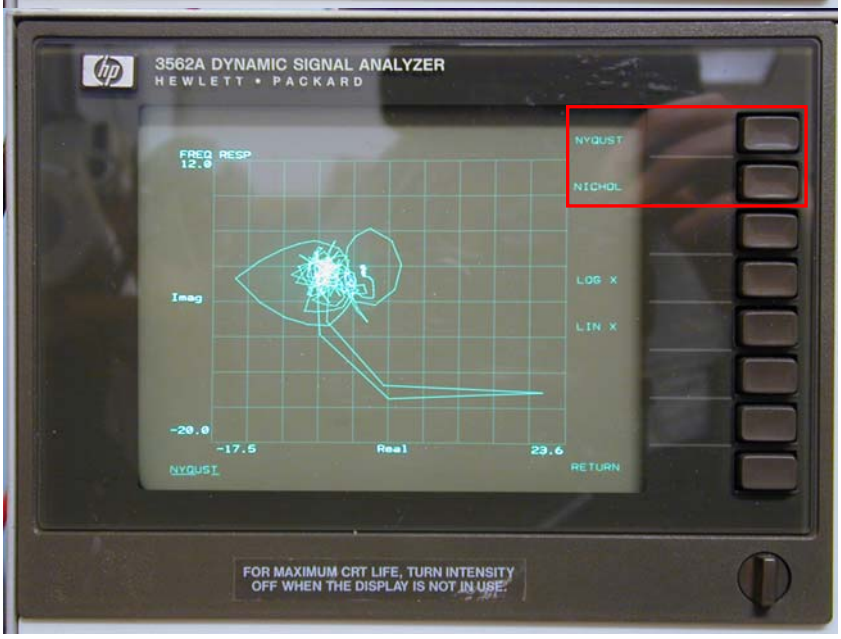
c.) Note also that the *.txt data format for **purely real quantities** is **801** rows of **2** columns (frequency and *e.g*. magnitude-squared $\tilde{G}_{x\star x}(f) = \tilde{x}^*(f)\cdot\tilde{x}(f) = \left|\tilde{x}(f)\right|^2$) ; the *.txt data format for **complex quantities** is **801** rows of **3** columns (frequency and *e.g*. $\mathrm{Re}\left\{\tilde{G}_{y\star x}(f)\right\}$, $\mathrm{Im}\left\{\tilde{G}_{y\star x}(f)\right\}$).

9.) <u>You can also look at (and/or read-out) *additional* spectral data</u>:

<u>For each selected plot/trace in 8.) above, you can also look at</u>:
a. DISPLAY: **DEFINE TRACE:** press: **COORD** button {see **blue** box on page 13 pix}
b. On the RHS of the CRT, can select/view displays of:

- **Mag (dB) (Magnitude, expressed in dB)**
- **Mag (dBm) (Magnitude, expressed in dBm {referenced to 1 mW})**
- **Mag (LOG) (Magnitude, plotted on $\log_{10}$ scale)**
- **Mag (LIN) (Magnitude, plotted on linear scale)**
- **Phase (complex quantities, only – *n.b.* also works for Ch1 (X) and/or Ch2 (Y))**
- **Real (real part of complex quantity)**
- **Imag (imaginary part of complex quantity)**
- **Use NEXT button: Nyquist (Nyquist Plot = Imag *vs.* Real plot – complex quantities only)**
- **Use NEXT button: Nichol (Nichol Plot = Mag (dB) *vs.* Phase plot – complex quantities only)**





Offline Data Analysis:

There exist MATLAB-based *.m file scripts located in the POM Backup Server Area (Access these via use of the shortcut "New P406POM Backup" on the desktop of POM PC):

\Common\MATLAB_Analyses\HP3562A_Spectral_Analyses

Copy the relevant MATLAB *.m script files to a subfolder the Local MATLAB Work folder on the PC – e.g. in a sub-folder that *you* create on the local PC for your *own* analysis:

C:\Program Files\MATLAB\R2012a\work\HP3562A_Spectral_Analyses\My_Analysis_Subfolder

Edit/modify these MATLAB script(s) for your own individual/specific needs. Don't hesitate to ask a POM TA for help in doing this! The MATLAB *.m scripts will a.) absolutely calibrate your spectral data data and b.) make plots of your absolutely-calibrated spectral quantities. You can save all of the plots (*.fig, *.pdf and *.png formats) using the corresponding Matlab *Save_Pix.m scripts – produces a Pix folder containing these plots. Rename this Pix folder to something meaningful/specific to your data analysis.

When you have completed analysis of your data on the local PC, you *must* copy the contents of your local MATLAB analysis My_Analysis_Subfolder to its corresponding location in the POM Backup Server (Note that *nothing* is backed up on any of the PC's in the POM lab!!!!):

\Common\MATLAB_Analyses\HP3562A_Spectral_Analyses\My_Analysis_Subfolder