Spectrum Analyzer Operating Guide

for the MSA

2/1/10

The MSA as Spectrum Analyzer
Introduction

This Guide is intended as a reference for the use of the MSA as a Spectrum Analyzer. Many of the procedures described here will also apply to use of the MSA as a Scalar or Vector Network Analyzer. The pages can be accessed by clicking on the blue headings below, or by using the Bookmarks tab.

The first set of pages describes the procedures for performing sweeps and creating and manipulating graph data:

Test Arrangement (1G)--Physical setup for measurement in Frequency Band 1G (0-1000 MHz).

Test Arrangement (2G)--Physical setup for measurement in Frequency Band 2G (1-2 GHz).

Test Arrangement (3G)--Physical setup for measurement in Frequency Band 3G (2-3 GHz).

Basic Sweep--Procedure for setting up and performing a sweep.

Markers--Placing and using markers.

Graph Appearance--Customizing the appearance of the graph.

Preference Files--Saving and loading preference files.

Reference Lines--Creating Reference Lines.

The next set of pages describes procedures for performing certain specific tasks:

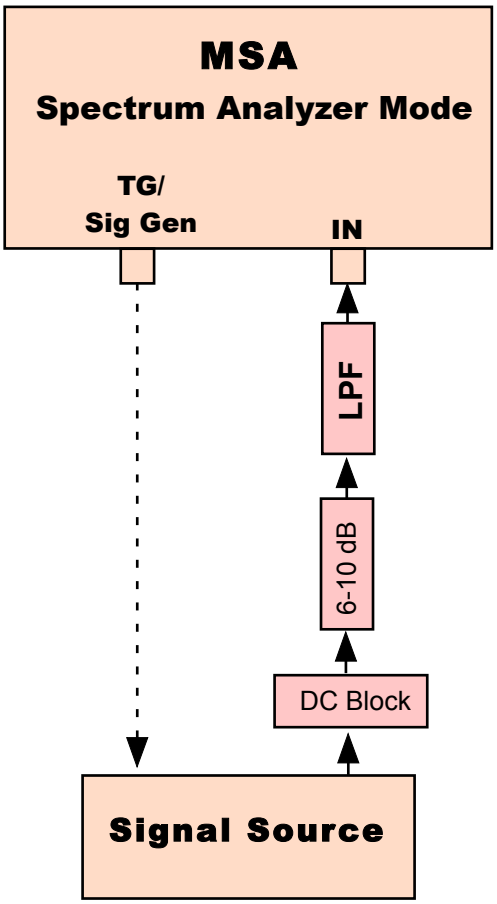
Tracking Generator--Using the Tracking Generator in Spectrum Analyzer with Tracking Generator mode.

Viewing Harmonics--Viewing a fundamental and its harmonics without stepping over any harmonics.

Warning: The MSA Graph window may be re-sized, but you should halt the sweep before doing so. Due to a Liberty Basic bug, re-sizing while a sweep is in progress will sometimes cause the program to crash.

Test Arrangement (1G)

Frequency Band 1G (0-1000 MHz)



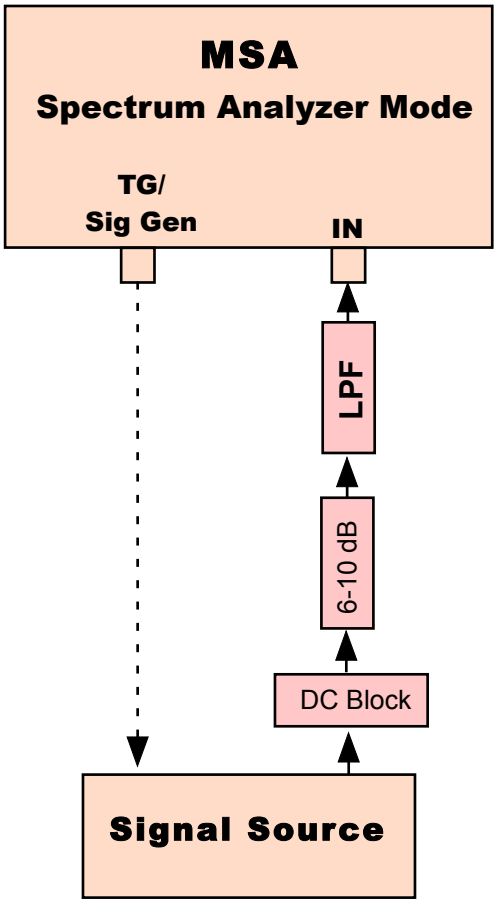
The Tracking Generator or Signal Generator output can optionally be used as a stimulus signal for the Signal Source. The DC Block, low pass filter and attenuator are optional, and provide the following benefits:

DC Block--This is a high quality capacitor to block DC, which can easily damage the input mixer.

Attenuator--The accuracy of the Spectrum Analyzer is dependent on the signal source having an output impedance near 50 ohms. The attenuator can be viewed as part of the signal source and helps accomplish this goal. Of course, the attenuation value must be added to the MSA reading to get the true signal level. The attenuator also provides protection against excessive input signals, and against accidental DC inputs.

Low Pass Filter--Input signals at or near the first IF frequency can be interpreted as signals at whatever frequency the MSA is tuned to. In addition, signals in the 2-3 GHz range can mix with LO1 in the same way as signals in the 0-1 GHz range, and be misinterpreted as such signals. If any such signals may be present, it is a good idea to filter them out. This can be done with a filter with a cutoff of 950 MHz or so, perhaps with a trap at the first IF frequency.

Test Arrangement (2G)
Frequency Band 2G (1-2 GHz)



The DC Block and attenuator provide the same functions as in Frequency Band 1G.

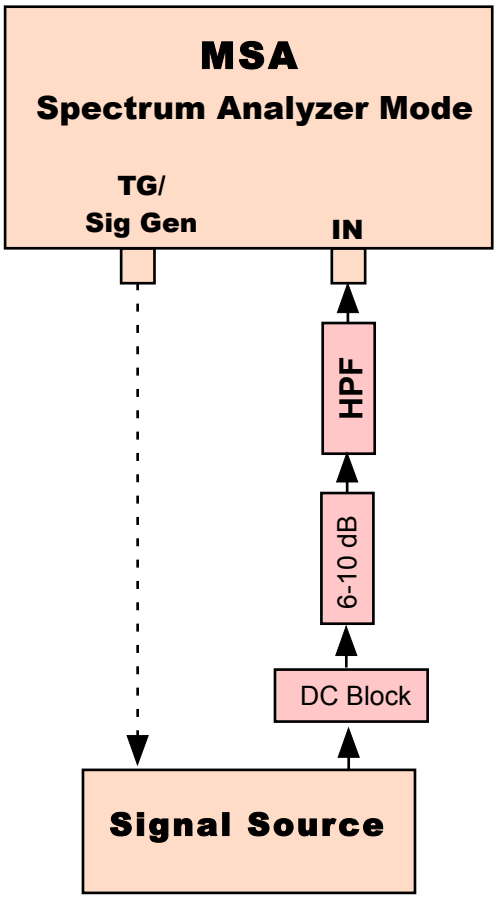
The Low Pass Filter is used only if necessary to block signals in the neighborhood of 10.7 MHz.

A hardware cabling change is also necessary to activate 2G mode, by running the output of Mixer 1 directly to the IF2 amplifier.

Note that when using the 2G Frequency Band in Spectrum Analyzer Mode every signal will produce two images, separated by twice the IF2 frequency, so it is most suitable for viewing a single signal or signals spaced such that they don't cause overlapping images.

Test Arrangement (3G)

Frequency Band 3G (2-3 GHz)



The DC Block and attenuator provide the same functions as in Frequency Band 1G.

The High Pass Filter replaces the Low Pass Filter of the 1G band. It needs to block signals below about 1050 MHz, to eliminate signals near the first IF frequency as well as 0-1 GHz signals that could be misinterpreted as 2-3 GHz signals.

Performing a Basic Sweep

The MSA performs a sweep by making measurements at specific frequencies within the specified range, waiting a specified time between measurements. The settings that control the sweep are set in the Sweep Parameters window, which is opened by (1) double-clicking just under the frequency axis labels, (2) double clicking on the setup information area in the upper right of the graph window, or (3) using the menu OptionsíSweep. The basic settings required for a sweep are as follows:

1. Final Filter Path and Video Filter BW. These must be set by hardware switches and then telling the MSA what those settings are.

2. Frequency range. Specify either the center frequency and span, or the start and stop frequencies.

3. Log or Linear sweep. Click the appropriate box. Linear sweep will always be used if the sweep range is narrow.

4. Number of steps per sweep (nSteps). The frequency range is divided into nSteps steps, resulting in measurement at nSteps+1 points. The more steps, the smaller the step size. In Spectrum Analyzer mode, if the step size exceeds the resolution bandwidth (final filter bandwidth), it is possible to step over signals.

5. Wait time (ms). The MSA waits this amount of time between measurements. In Spectrum Analyzer mode, the Wait time can be zero if the video filter is set to Wide, ___ or more if set to Mid, and ___ or more if set to Narrow.

6. Sweep direction. Normally set to L-R (left-to-right), but can be set to R-L or to Alternate.

7. Frequency Band. Normally set to 1G. The higher frequency bands are experimental.

8. Refresh Screen Each Scan.-If this box is checked, the graph is redrawn at the end of each scan, allowing marker positions to be updated, and eliminating erasure artifacts that result from continuous redrawing; but this also creates a "blink" at the end of each scan.

To perform a sweep, click Restart. The Restart button will change to Halt, and you can stop the sweep by clicking Halt. You may continue sweeping with the Continue button, or you may sweep just one additional step by clicking One Step. You may redraw the graph by clicking Redraw, which is sometimes useful to clean up the graph.

Markers

To place a marker on the graph, select the desired marker in the Marker box and double-click on the graph at the desired frequency. The marker will be placed on the trace at that frequency. If the Marker box shows None, double-clicking will place the L marker and cause it to be the selected marker. If the selected marker is already on the graph, selecting it in the Marker box and double-clicking on the graph repositions it.

When a marker is selected, it can be deleted with the Delete button, or its frequency can be changed by typing the desired frequency into the frequency box, or by clicking the "-" or "+" buttons above that box to move to the previous or next frequency point.

The sweep range can be altered to make the selected marker the center of the sweep by clicking Mark-->Cent. The change will take effect on Restart.

If the L and R markers have been placed, the sweep range can be altered to start at L and end at R by clicking Expand L-->R. If L is missing, it is treated as being at the far left; if R is missing, it is treated as being at the far right.

There are 6 markers numbered 1 to 6 that can be used for any purpose. The L and R markers can also be placed anywhere, and sometimes have special meaning, as in the case of Expand L-->R. There are two special markers, P+ and P-, which are automatically placed at the positive and negative peaks (i.e. maximum and minimum values). The positions of the P+ and P- markers are updated at the end of each sweep, unless Refresh Screen Each Scan is not selected (in the Sweep Parameters window), in which case the P+ and P- markers will not update until a Halt.

The frequency and graph value for each marker is displayed in the Marker information area under the graph. It is updated at the end of each sweep even if Refresh Screen Each Scan is off, except that in that case the P+ and P- marker information will not be updated until they are repositioned upon Halt.

The menu Options->Markers opens a window that allows the graphing of markers to be turned on and off. Even if markers are not graphed, the marker information will appear below the graph. That window also allows special use of the L and R markers. They may be used to limit the frequency range in which the P+ and P- markers will be placed. Alternatively, they may be automatically placed -3 dB below or +3 dB above the P+ or P- markers.

Changing the Graph Appearance

There are several aspects of the graph appearance that can be changed:

1. To change the number of divisions on the frequency axis, specify the number of divisions in the Sweep Parameters window. To change the number of vertical divisions, open either Y-Axis window by double-clicking just outside the Y axis, and enter the desired number of divisions.

2. The color and width of the graph traces can be set in Y-axis windows.

3. Also in the Y-axis windows, you can select a trace style: Off turns it off. Norm Erase draws the trace as a line, and erases the previous line as the sweep proceeds. Norm Stick draws the trace as a line but leaves all prior traces when drawing the current one. Histo Erase and Histo Stick are similar, but draw a vertical bar at each step rather than a continuous line from point to point.

4. The overall color scheme of the graph is selected in the Sweep Parameters window under Graph Appearance. There are two preset choices, and the user can create more as described below. Changing the Graph Appearance selection will override any previous choice of trace color, but that previous choice can be re-established as described above.

Creating new Graph Appearances:

1. Open Options-->Appearances

2. Click on the various color boxes to choose new colors. The sample graph will show the results.

3. There are various levels of permanency to your choices.

   a. If you click the Use button, the new colors will be used in the current graph until you change them. Once changed, there is no way to get them back as a group; they must be individually re-selected.

   b. If you click the Save as Preset button, a window will open allowing you to save the new color scheme as a named preset, which will appear in the Graph Appearance box in the Sweep Parameters window. This allows you to switch to another Appearance and back again.

   c. Whichever option you choose, once you quit the program, your new colors will disappear unless you use File-->Save Prefs to save a new preference file that will include these colors. If you do so, the next time the program runs, these colors will be used, and if you saved them as a preset, they will be listed in the Graph Appearance box.

Saving and Loading Preferences

On startup, the MSA software loads a preference file called Prefs.txt, which specifies the operating mode (Spectrum Analyzer, VNA Transmission or VNA Reflection) and most of the settings contained in the Sweep Parameters window and the Y-axis windows. After you have changed those settings, you can save the new settings in a preference file by using File-->Save Prefs. You may choose to replace the existing Prefs.txt file, or you may save under a new name.

You may load a preference file at any time using File-->Load Prefs, which will allow you to choose the file to load. You can use this feature to reload Prefs.txt to undo any changes you have made to the settings, or to load a preferences file you have saved under another name.

Save Prefs and Load Prefs can be used to make it easy to switch from one commonly used collection of settings to another, by saving each under a descriptive name. Just remember that if the changes include the video filter or final filter path, merely changing the software setting does not actually change the hardware setting, which must be done physically.

Reference Lines

Reference lines can be created in any mode. They may either be displayed on the graph, or combined with the graph data by addition or subtraction. They are accessed through the menu Options->Reference Lines. That menu item opens a window that allows you to specify the reference line type, which axes will have reference lines, and the color and width of the reference lines (if they are to be drawn). A reference line may be created for each axis, but if two are created they must both be of the same type. The reference line types are described below.

Fixed Value References

Fixed value references are created by selecting that type and entering the value for the appropriate axis. For example, if a value of -18 is specified, a horizontal line will be drawn at -18 on the selected axis, provided that the Graph Option "Data and Ref" is selected. That option means to graph both the data and the reference. Instead, you may perform subtraction or addition with the reference line, by selecting the appropriate Graph Option. For example, if you have a graph with a peak value of -18 dBm, and create a reference of -18, setting Graph Option to Data-Ref, the reference will be subtracted from the data so the peak will appear at 0 dBm, and all other graph values will effectively be dBc relative to that peak (though the axis will still be labeled as dBm).

Saved Data References

You may save the current data as a reference. This allows you to compare the current data to future scans, either visually or by subtracting one from the other. If you re-open the Reference Line window when you already have a data reference, and you keep that reference type, then when you close the window you will have the option to update to the current data, or to retain the old data. For example, if you just want to change the line color, you will want to retain the old data when closing the window. When data is saved, it is the underlying dBm value that is saved. But the saved data is converted to the current graph data before being used. For example, if a graph shows signal level in volts, the saved S11 data is converted to volts before being graphed or added/subtracted.

Reference lines are temporary objects, in that they are created for short-term use. They are not saved when you save Preferences or Test Setups. If you change the frequency range settings, any Saved Data Reference will disappear, but Fixed Value References will survive.

Tracking Generator

The basic Spectrum Analyzer mode is used to display the spectrum of externally generated signals. With the addition of a Tracking Generator (TG), the MSA can generate a signal at the same frequency to which it is tuned. That signal can be run through a device under test (DUT) to measure its response over frequency. This essentially turns the MSA into a network analyzer, though if it still does not have phase-measuring ability, it is a Scalar Network Analyzer (SNA) rather than a Vector Network Analyzer (VNA).

The MSA with TG can be operated in an SNA or VNA mode. Those modes are described in the VNA Operating Guide. However, the MSA also has a Spectrum Analyzer with Tracking Generator (SA+TG) mode, which is described here. This mode is essentially the same as operating as an SNA, but without automated calibration. For example, to scan a filter response in SA+TG mode, you first scan the TG to determine its signal level; the frequency range is likely small enough that the TG level is fixed over that range. You then scan the filter and mentally adjust the readings to account for the TG strength. For example, if the TG is -10 dBm and the response peak is -12 dBm, you know the real response is -2 dB at the peak. An SNA or VNA would perform this calibration adjustment automatically.

Many times, the user does not care about the true response level at the peak, but rather is judging the overall response using the peak as a reference level. For example, to find the -3 dB points, it is not necessary to know the TG level, because it is not necessary to know the absolute response at the peak. SA+TG mode is perfect for those situations.

The MSA TG has two unique features when in SA+TG mode that are especially useful for analyzing receiver IF circuitry:

1. TG offset. In the Sweep Parameters window, you can specify an offset frequency. The TG signal will be generated at the tuning frequency plus the offset. This lets you stimulate a mixer at one frequency while tuning to a different frequency to examine the IF signal.

2. TG reverse. In the Sweep Parameters window, you can specify that the TG should run in reverse. This means that as the MSA tuning frequency sweeps from the bottom to the top of the frequency range, the TG sweeps from the top to the bottom. This is useful for examining IF circuitry that inverts the IF.

Viewing Harmonics

To view a signal and its harmonics, you may do a normal sweep with a step size small enough that you will not step over any of the harmonics. This usually requires either a very small step size (large number of steps per sweep) or a wide bandwidth final filter. An alternative is to start the sweep at the fundamental frequency and make the step size equal to the fundamental frequency. Setting the trace style to Histo Erase will create a "bar graph" showing the level of the fundamental and each harmonic.

Determine the highest harmonic you want to view (count the fundamental as harmonic 1). Call this number H. Call the fundamental frequency F.

--Set the sweep start frequency to F.

--Set the sweep end frequency to H*F. (Make H=10 and this is easy)

--Set the number of steps to H-1 (H-1 "steps" is H "points")

This will place the fundamental at the left axis and the Hth harmonic at the right axis, and will cause each step to land directly on a harmonic. If you want to increase the number of steps, make it any integral multiple of (H-1).

To start the sweep at zero, set the start frequency to 0 and use H steps, or any multiple of H.