

Using Advanced Limit Line Features

MS2717B, MS2718B, MS2719B, MS2723B, MS2724B, MS2034A, MS2036A, and MT8222A

Economy Microwave Spectrum Analyzer, Spectrum Master™, and BTS Master™

The limit line features in the spectrum analyzer mode of the MS2717B, MS2718B, MS2719B, MS2721B, MS2723B, MS2724B, MS2034A, MS2036A and MT8222A make it easy for users to create sophisticated limit lines or spectrum masks or to use limit lines created by others. Limit lines can have from 2 to 41 inflection points. You can name a limit line as you save it and then use it at a different frequency. You can share limit lines you created with other people. To use all the features described in the note, the instrument must have spectrum analyzer code version V3.16 or greater.

In this application note you will learn how to create a limit line (a.k.a. emission mask) that meets the requirements of a document such as the FCC rules for broadcasters, WiMAX standards, CDMA emission mask standards, etc. and save the limit line for future use or sharing using the “Limit Advanced” features.

Creating a Limit Line

To begin creating a limit line or spectrum mask, press | Shift | Limit 6| to get to the limit line menu. When you are creating a limit line is easiest to start with a default limit line. The default limit line is a flat line 2.5 grid lines down from the top of the screen for an upper limit line or 2.5 grid lines up from the bottom of the screen for a lower limit line. The examples in this application note all refer to upper limit lines. The process to create a lower limit line is identical. Set the instrument's reference level to 0 dBm to make setting the amplitudes of the various inflection points easy. Make sure Upper is underlined then press the **Set Default Limit** soft key. The default limit line covers the current span of the instrument and has two inflection points, one at the left end and the other at the right end.

Technically you can choose any reference level you want, but by setting the top of the limit line to 0 dBm, all the inflection points, which are usually stated in dBc in most standards easy to enter without any mental arithmetic. The vertical position of the entire limit line can easily be moved to where it is needed at any time. You will learn how later in this application note.

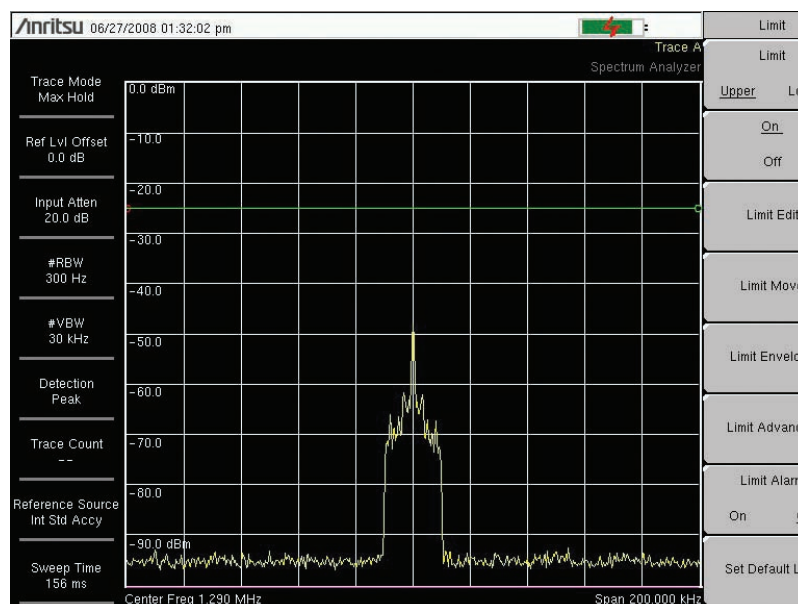


Figure 1: Default upper limit line at -25 dBm

Limit Line Type – Absolute or Relative

Limit lines can be created so each inflection point is tied to a particular frequency – what we call an **Absolute Limit Line** or, so each inflection point is relative to the instrument's center frequency, what we call a **Relative Limit Line**. You can change from one type to the other at any time so you aren't locked into a particular type once you start creating a limit line. You do that under the "Limit Advanced" menu.

Adding and Deleting Points

You can have up to 41 inflection points on a limit line. As you begin creating your limit line, select the type of limit line you want to create – Absolute or Relative. For most cases where the desire is to create an emission mask based on a standard, the relative format is easier to use.

To add a new inflection point select the inflection point immediately to the left of the area where you want to add an inflection point using the **Next Point Left** or **Next Point Right** soft keys in the Limit Edit menu. Press the Add Point soft key to insert a new inflection point half way between the active inflection point and the next one to the right. In the case of figure 2, the new inflection point is at 1.29 MHz. There is one exception to the adding of points. If the active inflection point is at the right hand edge of the display, a new inflection point cannot be inserted. However if the last inflection point on the right isn't at the right edge of the screen a new point can be added. It will be placed at the right edge of the screen.

Once a point is added you can move it in amplitude and frequency anywhere between the points bounding it on the left and right. As shown in figure 2, if you have two inflection points on a relative limit line, one at +100 kHz and the next at -100 kHz from the center frequency, an inflection point added between the two points will be at a relative frequency of zero Hz, exactly on the center frequency and can be adjusted from just above -100 kHz to just below +100 kHz.

Adding a Vertical Segment

Most emission mask specifications look something like this:

0 to 10.2 kHz	0 dBc
10.2 kHz to 25 kHz	-30 dBc
25 kHz to 40 kHz	-46 dBc
40 kHz to 75 kHz	-70 dBc
>75 kHz	-80 dBc

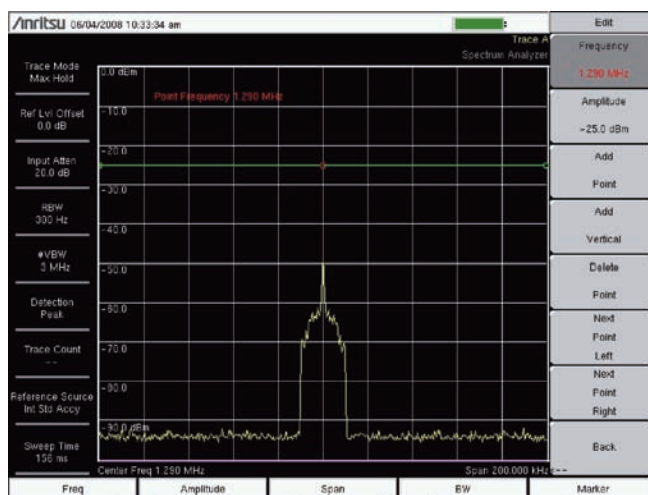


Figure 2: Inserting an Inflection Point between to Inflection Points

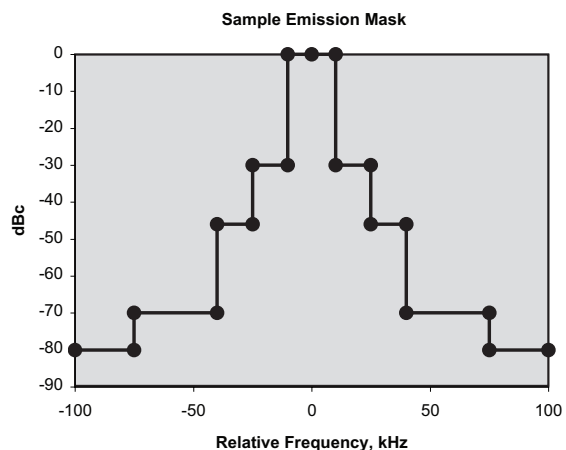


Figure 3: The specified emission mask

By using “Add Vertical” to insert vertical segments the creation of such an emission mask is quick and easy.

Set the span to cover the width of the emission mask or a little more if desired.

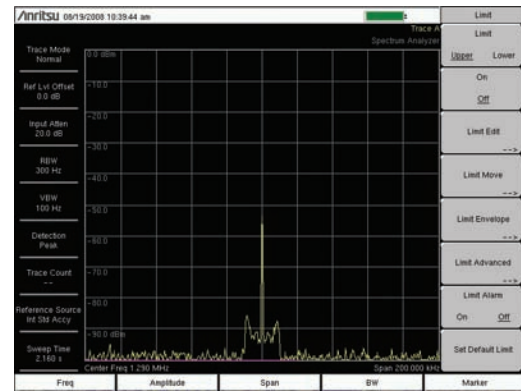


Figure 4: Getting Started

Set a default limit line.

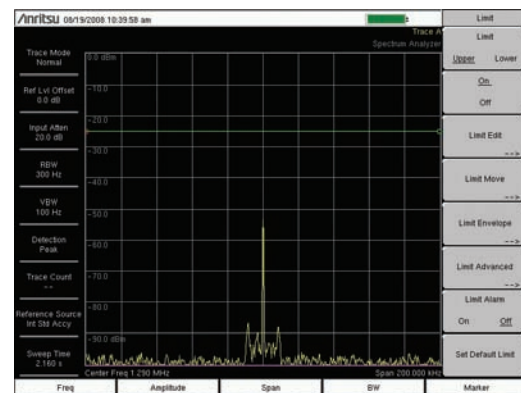


Figure 5: The default limit starting point

Add an inflection point at the center frequency by making the inflection point at the left end of the limit line active and pressing **Add Point**.

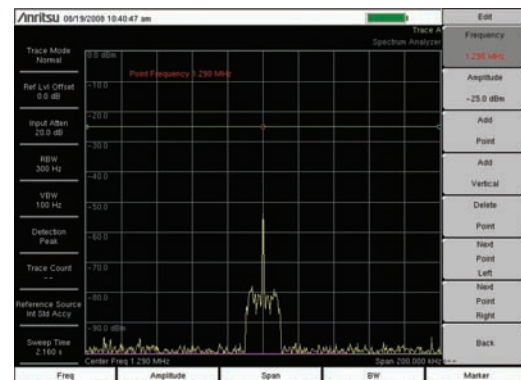


Figure 6: Adding point at center

The default limit line type is **Absolute**. Go to the Limit Advanced menu and change the limit line type to **Relative**.

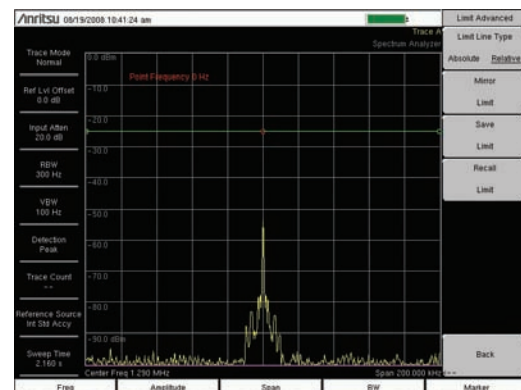


Figure 7: Changing Limit Line to Relative

With the inflection point in the center active, press the **Add Vertical** soft key. This adds two inflection points at the same frequency and at slightly different amplitudes so you can see both of them.

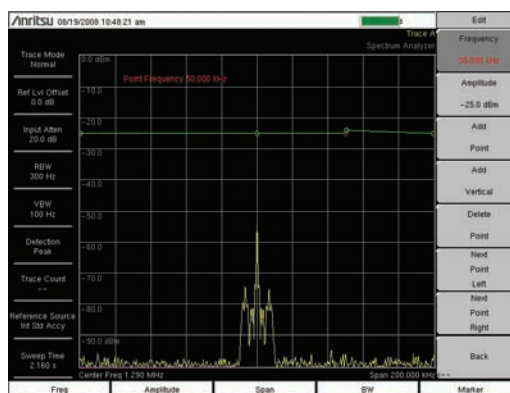


Figure 8: Adding a Vertical Segment

Adjust the frequency of the inflection point to place it where it is needed, 10.2 kHz in the example above. Set the amplitude of that point to 0 dBm. Change the amplitude of the 0 Hz point to 0 dBm by pressing Next Point Left and adjusting the amplitude of the point.

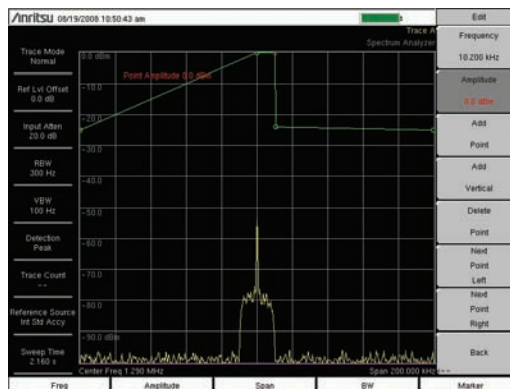


Figure 9: Adjusting vertical segment

Press the **Next Point Right** soft key twice and set the amplitude of inflection point to -30 dBm. Notice that the frequency of this second point of the pair is the same as the first of the pair.

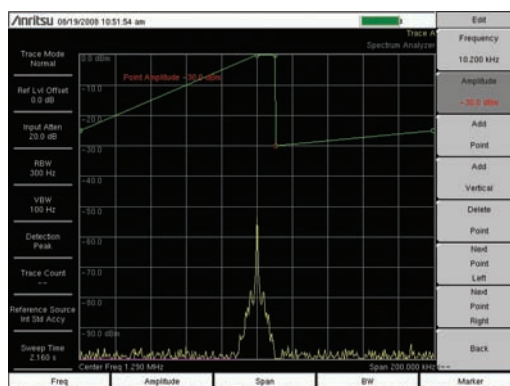


Figure 10: Adjusting amplitude of the second inflection point of the pair

Add another vertical segment and move its frequency to +25 kHz and the amplitudes to -30 dBm and -46 dBm

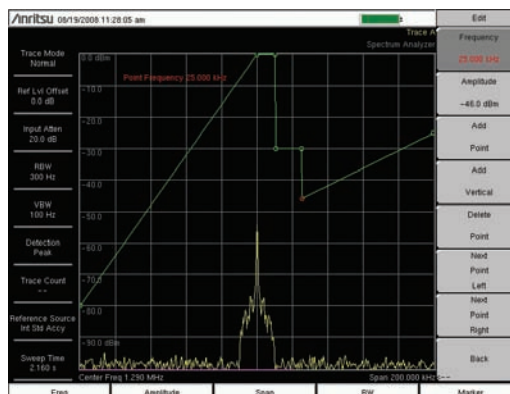


Figure 11: Adding another vertical segment

Add a vertical segment at 40 kHz with amplitudes at -46 dBm and -70 dBm.

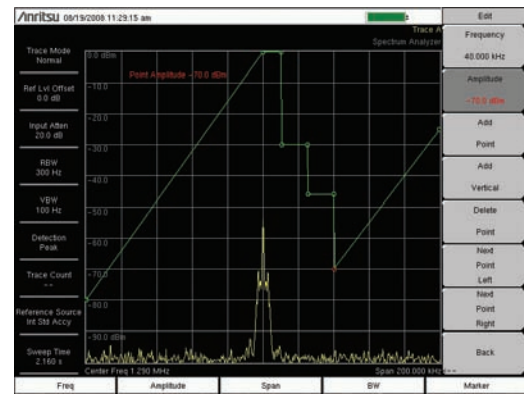


Figure 12: Another vertical segment

Add a final vertical pair at 75 kHz with -70 dBm and -80 dBm levels.

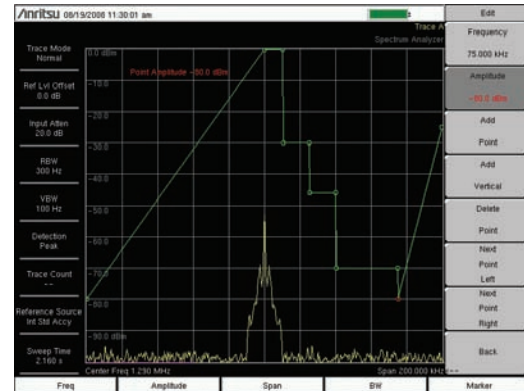


Figure 13: The last vertical pair

Adjust the amplitude final point to -80 dBm..

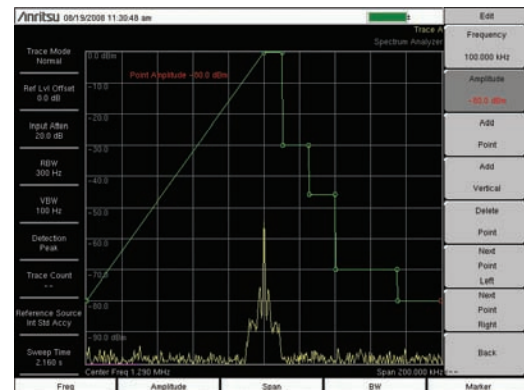


Figure 14: Adjusting the last point

In this step we create the left side of the emission mask. To do this, go to the Limit Advanced menu and press the **Mirror Limit On Off** soft key. This automatically generates the other side – regardless of whether you created the left side or the right side of the emission mask first.

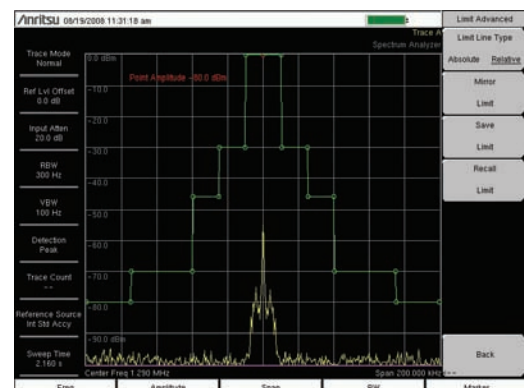


Figure 15: Mirror Limit used to create the other side

Adjusting a Vertical Segment

A vertical segment has three values that can be adjusted – the frequency of the segment, the amplitude of the first point in the segment and the amplitude of the second point of the segment. The amplitude values are adjusted independently of each other while adjusting the frequency of either inflection points adjusts the frequency of the other inflection point identically.

Options for Moving Limit Lines

Move Limit to Current Center Frequency

Regardless whether a limit line was created as a relative or absolute limit line, a limit line that is turned on can be moved to the current center frequency by a single button press.

Move Limit by dB

With this soft key you can adjust the vertical position of the limit line by increments as small as 0.1 dB, allowing you to place the limit line exactly where you want it to be. The soft key always says **Move Limit 0.0 dB**. If it is active for editing the 0.0 dB portion will be red. Simply turn the knob or key in the desired value and the entire limit line will move up or down by the amount you entered. Enter a negative value by using the \pm key to make a negative value.

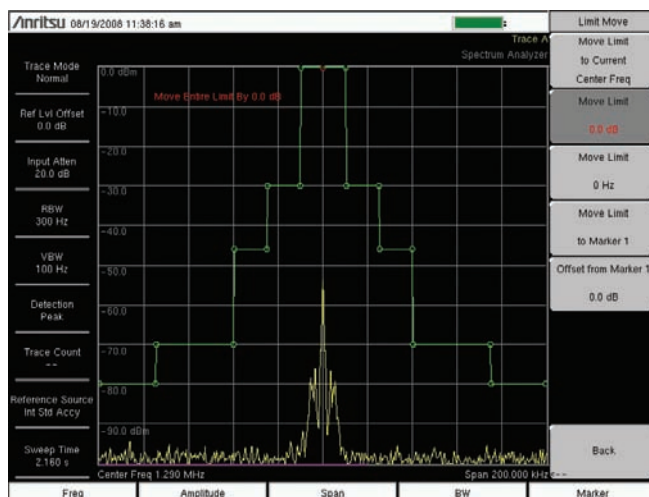


Figure 16: Limit Move Menu

Move Limit by Frequency

You can move the entire limit line by the desired number of Hertz, kHz, MHz or GHz by making this key active for editing and turning the knob or keying in the amount you want the limit line to move.

Move Limit to Marker 1

With the button you can move a limit line to the frequency and amplitude of the signal that you want to measure.

- For an AM signal simply place the marker on the carrier and press the **Move Limit to Marker 1** soft key.
- For a wideband FM signal set the RBW to 100 kHz and place marker 1 on the peak of the signal. Then press the **Move Limit to Marker 1** soft key. After that set the RBW to 3 kHz to make the measurement.
- For noise-like signals such as CDMA where there is no easily discernable carrier frequency, manually place marker 1 at the center frequency before using this function.

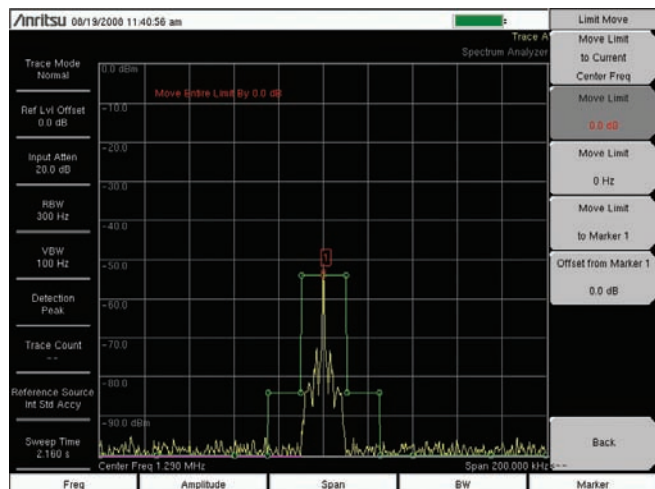


Figure 17a: Move Limit to Marker 1
(Limit line moved to Marker 1)

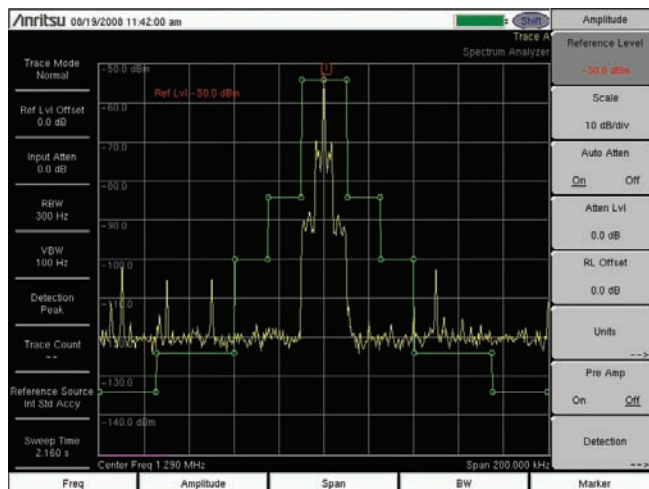


Figure 17b: Move Limit to Marker 1
(Reference level set to see measurement)

Offset from Marker 1

When you are intending to use the instrument's "Save on Event" functionality, generally you want the limit line offset from the signal so not every sweep is saved, but only those that exhibit some extraordinary situation.

Use Offset from Marker 1 to specify the how far the limit line should be from the amplitude of the marker.

Creating Limit Envelopes

Often there is a need to determine when unknown signals appear in the midst of known signals. In the past creating a limit line to exclude known signals could be quite tedious and time consuming in a complex signal environment. The ability to automatically create limit envelopes has made the process almost instantaneous.

Automatic Creation

When setting up a trace prior to automatic creation of a limit envelope, it is most effective to set the instrument the same way it will be used when using the limit envelope. Generally this means to set the instrument to operate over the same frequency range, with the same reference level, same attenuation and preamplifier settings. There is no technical restriction requiring any of this to be done, it just is the easiest way to get a useful limit envelope.

Once you are satisfied with the instrument's settings, press <Shift> <Limit> <Limit Envelope> <Create Envelope> to automatically create an envelope. There are several adjustments that can be made to the envelope once it is created to make sure it is the best it can be for your intended purpose. Automatic creation works both with upper limit lines and lower limit lines.

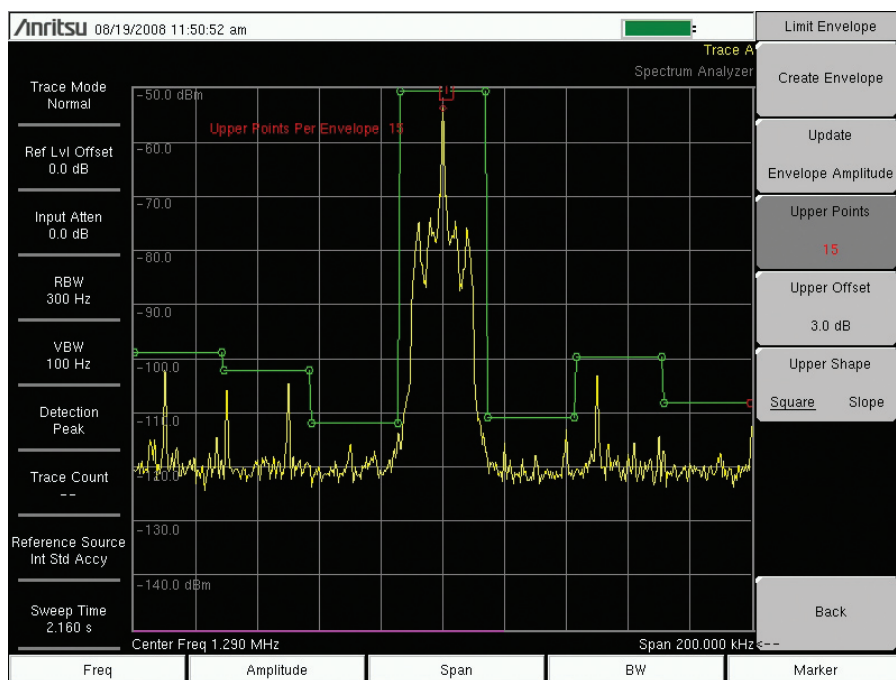


Figure 18: An automatically Created Limit Envelope

Adjustments

If there are a lot of signals on-screen you very likely will need to tweak some of the inflection points to be sure that the critical points are covered the way you want them to be. In addition to that, using the limit line editor you can add and delete inflection points, up to a maximum of 41, as well as adjust the amplitude and frequency of each point.

Update Envelope Amplitude

After an envelope has been created, this soft key adjusts the amplitude of the inflection points to make sure the limit line is above the sweep that is on screen when the key is pressed.

Number of Points

The number points can be set anywhere from 2 to 41. The optimum number of points depends on the signals on screen and their spacing. The easiest way to find the best number is to simply press the up and down arrow buttons or turn the knob to select different values to what works best. When you change the number of points, a new envelope is immediately and automatically created. All selections should generate a limit envelope that is above all the signals; the more points are used the closer it will follow the signals.

Offset

Use the Offset feature with the limit envelope to reduce the chances that a small variation in the strength of a known signal will cause alarms or automatic trace saving to occur too frequently. The offset value can be positive or negative.

Square vs. Sloped

The better choice here depends on the nature of the signals on screen. For signals such as CDMA or other digital signals such as 64QAM microwave link signals, a square envelope probably will be better. If there are mostly narrow-band signals then a sloped limit envelope will usually be more useful.

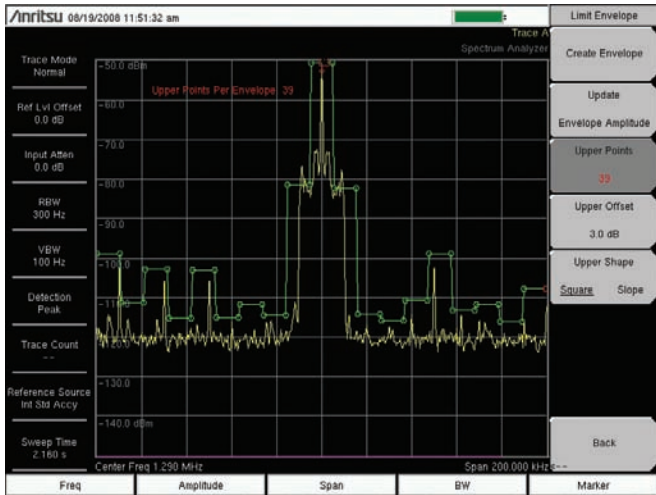


Figure 19: Square Limit Envelope

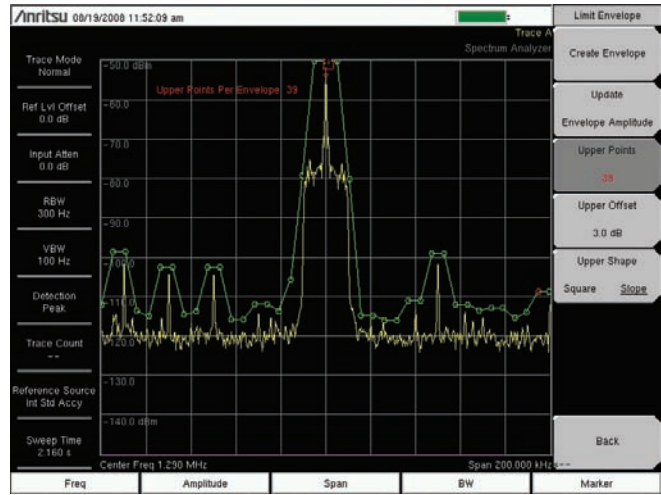


Figure 20: Sloped Limit Envelope

Advanced Limit Line Features

Limit Line Type – Absolute or Relative

Limit lines are used in two different ways. Absolute and Relative limit lines are reflective of those two ways. When you are using an absolute limit line, each inflection point is tied to a particular frequency. When such a limit line is saved and recalled it returns to the same frequencies at which it was created. You would use this sort of limit line when the signals you are measuring are always at the same frequencies.

Use a relative limit line when you are making measurements of similar signals at different frequencies, such as CDMA channels, AM and FM broadcast proofing. This way you can build a limit line once and then use it over and over again at different frequencies. A relative limit line, when recalled, is centered on the current center frequency of the spectrum analyzer, regardless of the frequency at which it was created.

You can switch a limit line from one type to the other simply by selecting the type you want by pressing the soft key. If you saved an absolute limit line when you intended to build a relative limit line, you can easily move it to the current center frequency by pressing the Move Limit to Current Center Freq soft key in the Limit Move menu.

Mirror Limit

Most spectral masks that standards call for are symmetrical. With that in mind this feature was added to the product. Mirror Limit can be used in either of two different ways.

- You can build one side of the spectral mask and then turn on **Mirror Limit** to automatically build the other side.
- You can turn on Mirror Limit before building your spectral mask. That way when you add or edit an inflection point on one side of the spectral mask, the same action is automatically performed on the other side.
- You can combine the two methods by turning on **Mirror Limit** part way through the spectral mask building process.

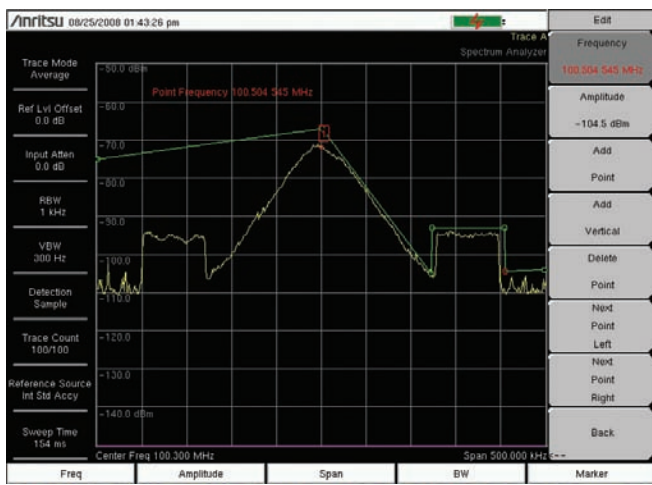


Figure 21: Half the Spectrum Mask Built

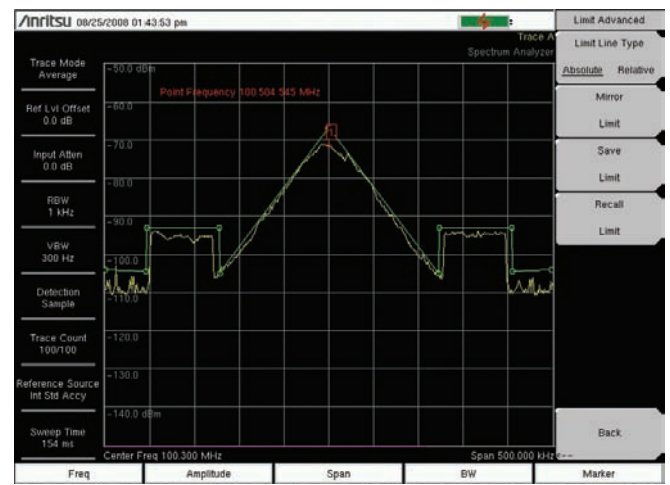


Figure 22: Press Mirror Limit to Build the Other Half

Saving and Recalling Limit Line

Limit lines can be saved independently of measured signals. There are two locations to save and recall limit lines, under the | Limit | Limit Advanced | menu, and under the | File | Save | and the | File | Recall | menus. When you are saving a limit line, it must have a name that is different than any other limit line in the instrument – in other words, you can't overwrite existing limit line files.

Sharing Limit Lines

One of the primary benefits of savable limit lines is the ability to create them one time and copy them to multiple instruments. There are several ways to copy a limit line into an instrument. Limit line files are small – around 23 kB – so they can easily be sent as an e-mail attachment. When you get one this way, save the attachment on your computer in a directory you will remember – maybe one called “limit_lines”. You can then copy the limit line file into an instrument using any of these methods.

Using Master Software Tools to Create or Edit Limit Lines

Open Master Software Tools (MST) – version 2.12 or higher - and connect to the instrument using either a USB connection or a LAN connection. You can use Master Software Tools to edit limit lines stored on the computer or in the instrument.

To edit a limit line stored on the computer use | File | Open | and navigate to the directory where you stored the limit line file. Select the file and click **Open**. This will open the limit line for editing.

With the file in the limit line editor you can

- Add and delete points
- Move points by dragging them with the mouse
- Enter the desired frequency and power level in the inflection point list.
- Make a pair of inflection points a “vertical pair”
- Change the center frequency and span of the limit line
- Change several inflection points simultaneously
- Toggle between Absolute and Relative types
- Save the limit line on the computer
- Upload the limit line into an attached instrument

The pairs of inflection points in the list that are highlighted yellow are a vertical pair. That means that their frequencies are the same, but their amplitudes can be different. In the graph, vertical pairs are shown with white inflection points. You can drag one of the inflection points of a vertical pair to a different frequency and the other point changes along with it. You can also type the frequency value in the table for one point and the other one changes too. This particular limit line would normally be built almost entirely of vertical segments. Only two of the segments were made vertical segments in this example to make the special status of the yellow highlighting more obvious.

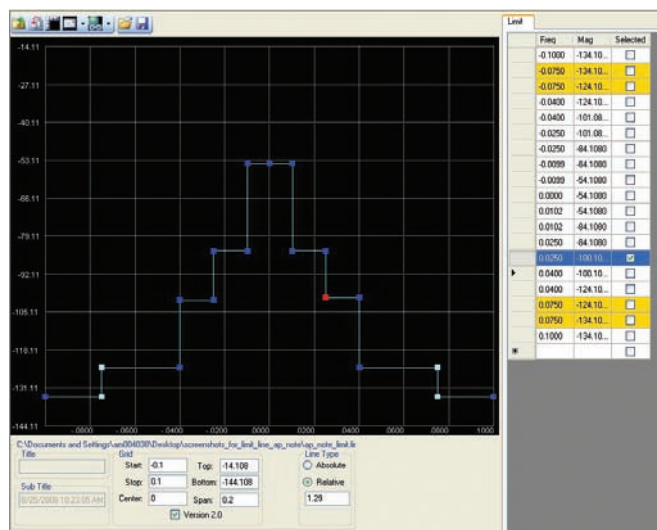


Figure 23. MST Limit Line Editor

Add a new inflection point by right-clicking on the inflection point that is left of the spot where you want to add a point. From the list select Add Node. Here is the entire right-click menu.

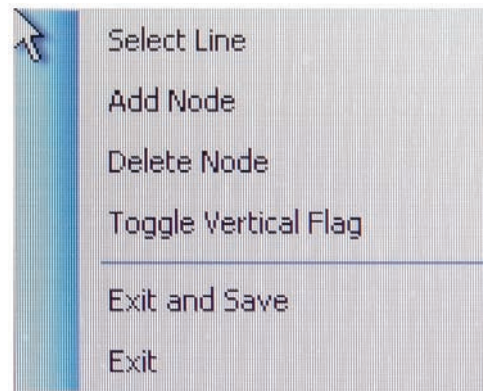


Figure 24. Limit line node right-click menu

When you are creating a vertical segment, highlight the left end of the segment, right click and click "Toggle Vertical Flag". That will cause the inflection point to the right to be moved to the same frequency with no change to its amplitude

The red inflection point is the one that is currently active for editing. The blue highlighting in the list shows the same thing.

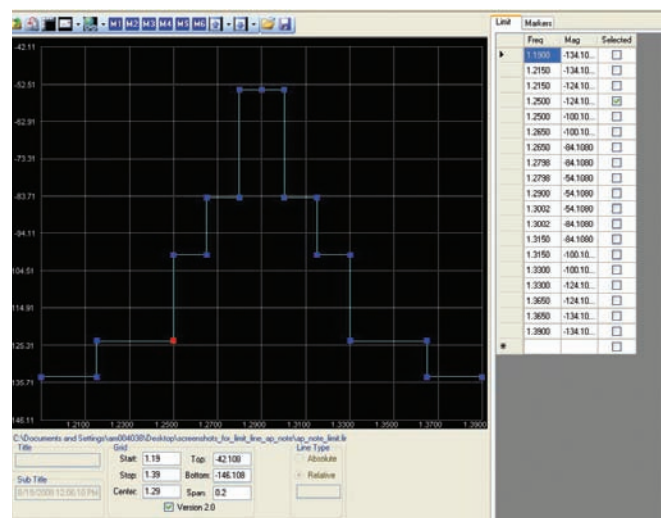


Figure 25: Editing Relating Limit Line in Master Software Tools

Since this is a relative limit line the horizontal axis is zero in the center with plus and minus delta values. For an absolute limit line the center value is the center frequency. At any time you can toggle between absolute and relative limit line types. The data entry box in the Line Type area is a user-defined center frequency that is applied when a relative limit line is switched to absolute.

You can select more than one inflection point by either clicking the boxes in the table or by holding the Control key down while either clicking on the inflection points in the graph or by using the mouse to create a box around the points you want to select.

After selecting several inflection points you can move them simultaneously by holding down the control key while dragging them with the mouse.

In MST click | Sync | Upload Active Window | to copy the limit line into the connected instrument.

Using a USB Stick

After you have copied all the limit lines into your computer, plug in a USB Stick and, if it is the first time you are using a particular type of USB stick, wait for the computer to acknowledge it is ready for use.

- Navigate to the USB stick using Windows Explorer. Create a directory on the USB stick called **usr** if it doesn't already exist. Copy the limit lines you want to put on the instrument into the **usr** directory. Safely disconnect the USB Stick from the computer and plug it into the instrument.
- On the instrument click | Shift | File | Directory Management |. Click on the **Current Location** soft key to underline **USB**.
- Click on the **Copy To Destination** soft key to underline **Int**.
- Click the **Copy From Current Location To Destination** soft key to copy all contents of the usr directory on the USB stick into internal memory.
- After copying is complete, press the **Current Location** soft key to underline **Int**.

The method works on the MS2721B, MS2723B, MS2724B, MT8222A, MS2717B, MS2718B, MS2719B, MS2026A and MS2036A.

Save On Event

You have the option to save a sweep in which a signal occurs that exceeds either the upper or lower limit line. This is used when tracking down signals that pop up where they don't belong. Applications for this include spectrum clearing before beginning service of a new service and for traditional interference sleuthing where undesired signals appear occasionally and disrupt communications.

Save-on-Event Menu

To simplify the job of creating a limit line that excludes known signals, a limit envelope can be automatically created with anywhere from 2 to 41 inflection points and offset from the existing signals and noise by the number of dB you select. You can choose the number of deflection points to optimize the envelope based on the complexity of the signal environment. When you change the number of inflection points, which is easily done by turning the knob, the envelope is immediately and automatically recreated so it is trivial to decide the best number of inflection points.

Limit Alarm

If you want to be audibly alerted when the limit line is exceeded, then limit alarm is for you. A sound is generated whenever any point on the sweep exceeds either the upper or lower limit line. To turn on limit alarm press | Shift | Limit | Limit Alarm | to underline On. The alarm works for both upper and lower limit lines.

Conclusion

The flexibility and choices available for limit lines makes this an easy-to-use choice even when the requirements are complicated.

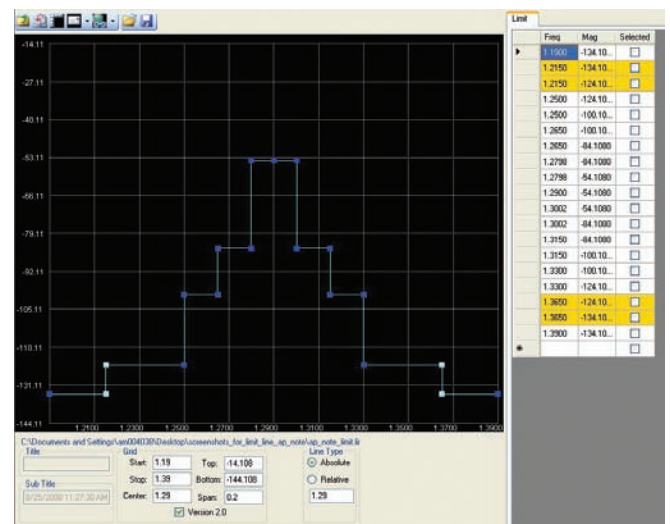


Figure 26. Absolute Limit Line

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