PART THREE

WAVE ANALYZER

(WAVA OPTION)

CHAPTER THIRTEEN: *Parameters*

In this chapter, see how

To set up for histograms

A Valuable Tool for Waveform Analysis

The WaveAnalyzer option added to your Waverunner oscilloscope provides a valuable tool for data analysis and the interpretation of measurement results: the histogram. With WAVA, histograms of waveform parameter measurements can be created, statistical parameters determined, and graphic features quantified for analysis.

Statistical parameters such as mean, standard deviation and median are extremely useful, but alone are usually insufficient for determining whether measured data distribution is as expected (see Chapters 4 and 11). Histograms expand the use of parameters to enhance your understanding by offering visual assessment of this distribution and revealing: **distribution type**, such as normal or non-normal, helpful for determining whether the signal behaves as expected; **distribution tails and extreme values**, which can be observed, and which may be related to noise or other infrequent and non-repetitive sources; and **multiple modes**, observable and possibly indicative of multiple frequencies or amplitudes, which can be used to differentiate from other sources such as jitter and noise.

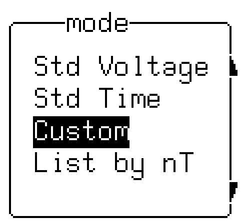
SET UP FOR HISTOGRAMS

Histograms are based on settings that include bin width and number of parameter events. The Waverunner scope with WAVA uses special parameters for determining histogram characteristics such as mean, median, standard deviation, number of peaks and most populated bin.

But before you can create a histogram, you must first set up the parameters you have chosen:

4. Press 

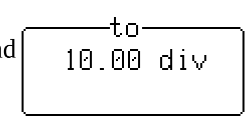
to display the MEASURE menus.

5. Press the button to select **Parameters**, and the button for 

Use 

if desired.

6. Set start and end points for the measurements with 

and 

Parameters are used to perform waveform measurements for the section of a waveform lying between the parameter cursors (Fig. 1.1, item ❶). The position of the parameter cursors is set using the **from** and **to** menus, and controlled by the associated menu knobs. The top trace in the figure below shows a sine wave on which a **freq** parameter measurement (❷) is being performed, with a value of 202.442 kHz as the average frequency. The bottom trace shows a histogram of this parameter and a value of 201.89 kHz (❸) — the average frequency of the data contained within the parameter cursors.

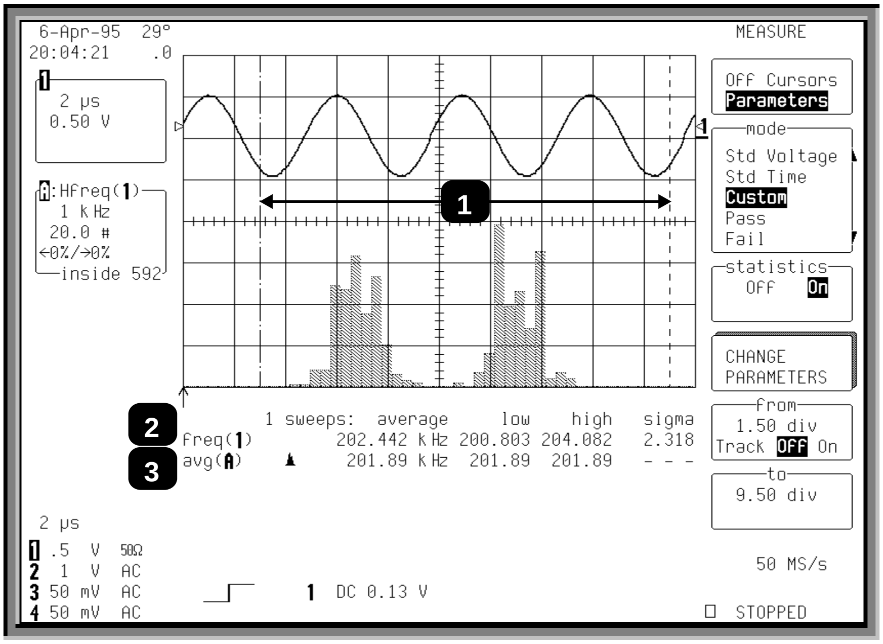


Figure 1.1

4. Press the button to select CHANGE PARAMETERS and access the CHANGE PARAM menus.

As shown in Figure 1.2, up to five parameters can now be selected, each displayed on its own line below the grid. Categories are provided for related groups of parameter measurements. The freq measure parameter from the "Cyclic" category for Trace 1, previously selected, is displayed on Line 1 as **freq(1)** (Item ❶). The **avg** measure parameter from the "Statistics" category for Trace A is displayed on Line 2. This category provides histogram parameters, while avg offers the mean value of the underlying measurements for the Trace A histogram section within the parameter cursors (❷), shown as "avg(A)" in ❸. Additional parameter measurements can be selected from "Category" and "measure". No parameters have been selected for Lines 3 to 5

5. After selecting a category, choose a parameter from the "measure" menu. Then select the parameter display line from the "On line" menu.

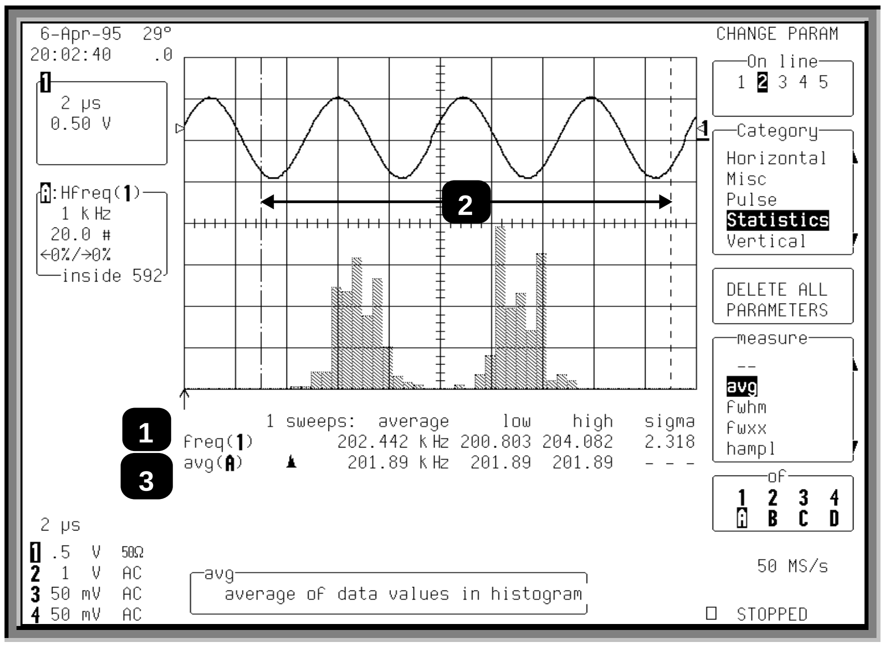


Figure 1.2

If a parameter has additional settings that you must supply in order to perform measurements, the **MORE 'xxxx' SETUP** menu appears. But if no additional settings are required the **DELETE ALL PARAMETERS** menu appears, as shown here: pressing the associated menu button clears the results in all five lines of parameters.

PARAMETER-VALUE CALCULATION AND DISPLAY

When you are not using persistence, the display for input channels shows the captured waveform of a single sweep. For non-segmented waveforms, the display is identical to a single acquisition. But with segmented waveforms, the result of a single acquisition for all segments is displayed.

The value displayed for a chosen parameter depends on whether "statistics" is on or off. And on whether the waveform is segmented. These two factors in addition to the parameter chosen determine whether results are provided for a single acquisition (trigger) or multiple acquisitions. In either case, only the waveform section between the parameter cursors is used.

If the waveform source is a memory (M1, M2, M3, or M4) then loading a new waveform into memory acts as a trigger and sweep. This also applies when the waveform source is a zoom of an input channel, and when a new segment or the "All Segments" menu is selected.

With "statistics" off, the parameter results for the last acquisition are displayed. This corresponds to results for the last segment for segmented waveforms with all segments displayed. For zoom traces of segmented waveforms, selection of an individual segment gives the parameter value for the displayed portion of the segment between the parameter cursors. Selection of "All Segments" provides the parameter results from the last segment in the trace.

With "statistics" on, and where the parameter does not use two waveforms in calculating a result (Δdly, Δt@lv), results are shown for all acquisitions since the CLEAR SWEEPS button was last pressed. If the parameter uses two waveforms, the result of comparing only the last segment per sweep for each waveform contributes to the statistics.

The statistics for the selected segment are displayed for zoom traces of segmented waveforms. Selection of a new segment or "All Segments" acts as a new sweep and the parameter calculations for the new segment(s) contribute to the statistics.

Depending on the parameter, single or multiple calculations can be performed for each acquisition. For example, the period parameter calculates a period value for each of up to the first 50 cycles in an acquisition. When multiple calculations are performed, with "Statistics" ***Off*** *the parameter result shows the average value of these calculations. Whereas* ***On*** *displays the average, low, high, and sigma values of all the calculations.*

In Figure 1.3, below, the upper trace shows the persistence display of a signal. The initial suggestion is of frequency drift in the signal source. The lower trace shows a histogram of the frequency as measured by the oscilloscope.

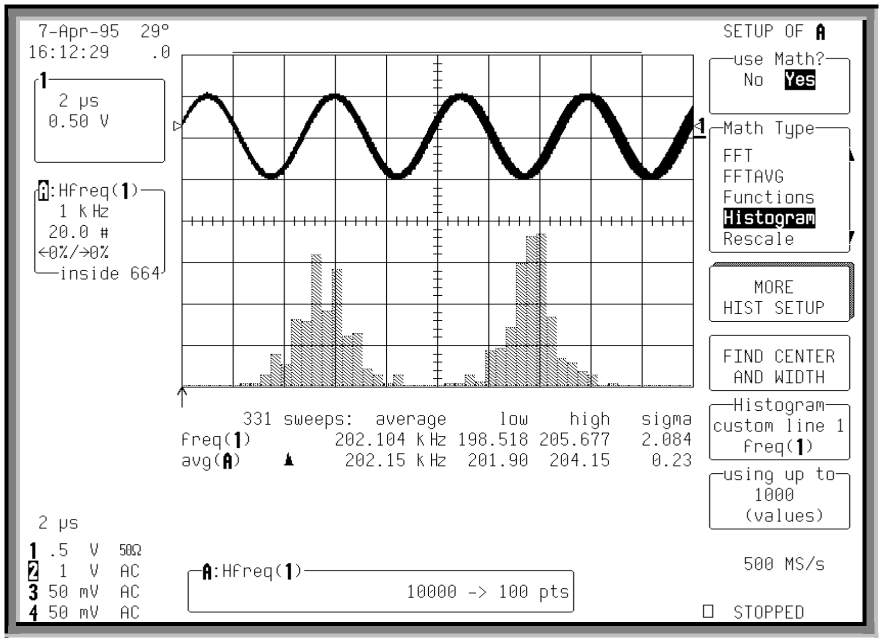


Figure 1.3

This histogram indicates two frequency distributions with dominant frequencies separated by 4000 Hz. There are two distinct and normal looking distributions, without wide variation, within each of the two. We can conclude that there are two dominant frequencies. If the problem were related to frequency drift, the distribution would have a tendency to be broader, non-normal in appearance, and normally there would not *be two distinct distributions.*

After a brief visual analysis, the measurement cursors and statistical parameters can be used to determine additional characteristics of distribution, including the most common frequency in each distribution and the spread of each distribution.

Figure 1.4, below, shows the use of the measurement cursor (Item ❶), to determine the frequency represented by one bin of the distribution. The value of the bin, inside the Displayed Trace Field is indicated by ❷.

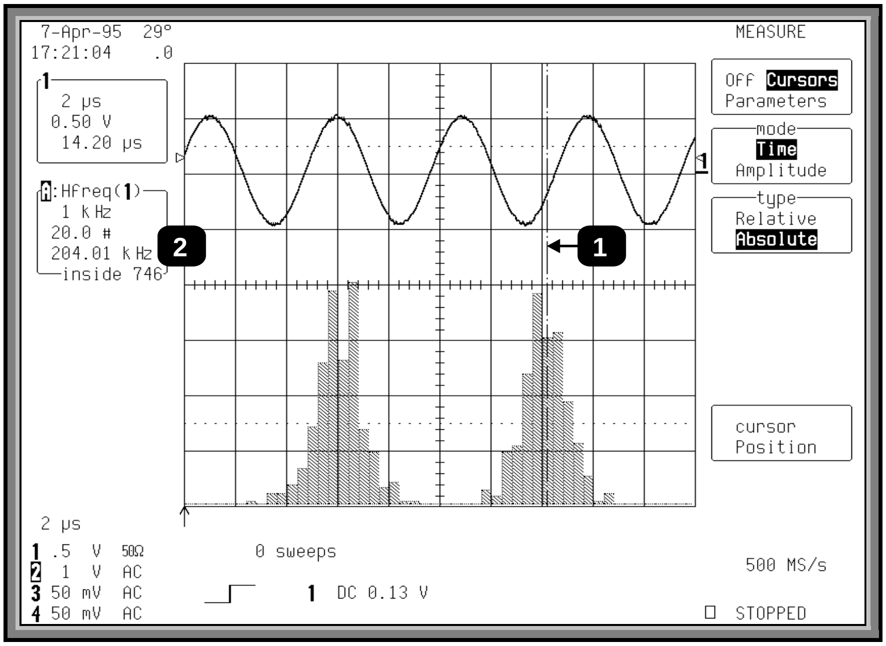


Figure 1.4

Figure 1.5, below, shows the use of the parameter cursors (Items ❶ and ❷) in determining the average frequency of the distribution located between the cursors. The average value of the measurements in the right-hand distribution is indicated by ❸.

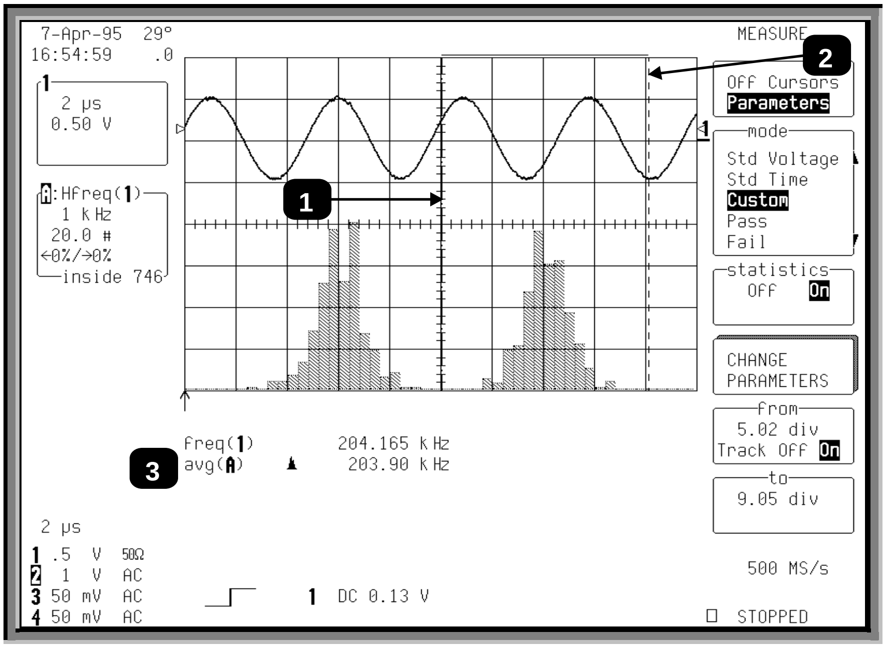


Figure 1.5

Finally, Figure 1.6 shows the use of the measurement cursors (Items ❶ and ❷) in determining the difference in frequency between a bin in the center of each distribution. The value in kHz, in the Displayed Trace Field, is indicated by ❸.

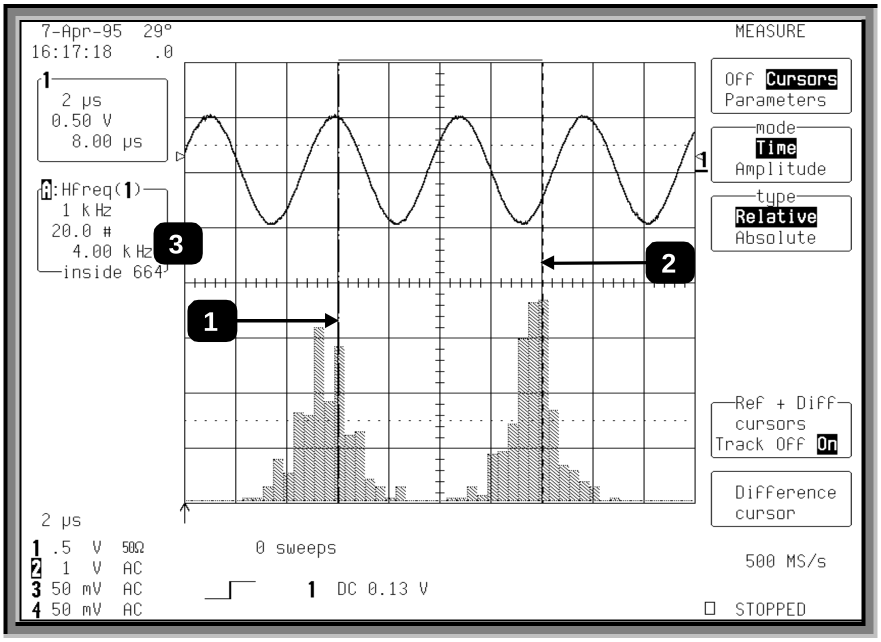


Figure 1.6

Parameter Math

LeCroy's WaveAnalyzer option also gives you the ability to perform arithmetic operations (addition, subtraction, multiplication, division) on the results of two parameter measurements. By customizing parameters in this way, you can effectively extend the range of parameter measurements based on your particular needs.

For example, suppose you need to measure the crest factor of a waveform. Traditionally, you would select the peak-to-peak and rms parameters, then manually compute the ratio of peak-to-peak to rms. Figure 1.7, on the other hand, shows how parameter math was used to configure crest factor as a calculated parameter. The list of custom parameters comprises 5 calculated parameters labeled **calc1** through **calc5**.

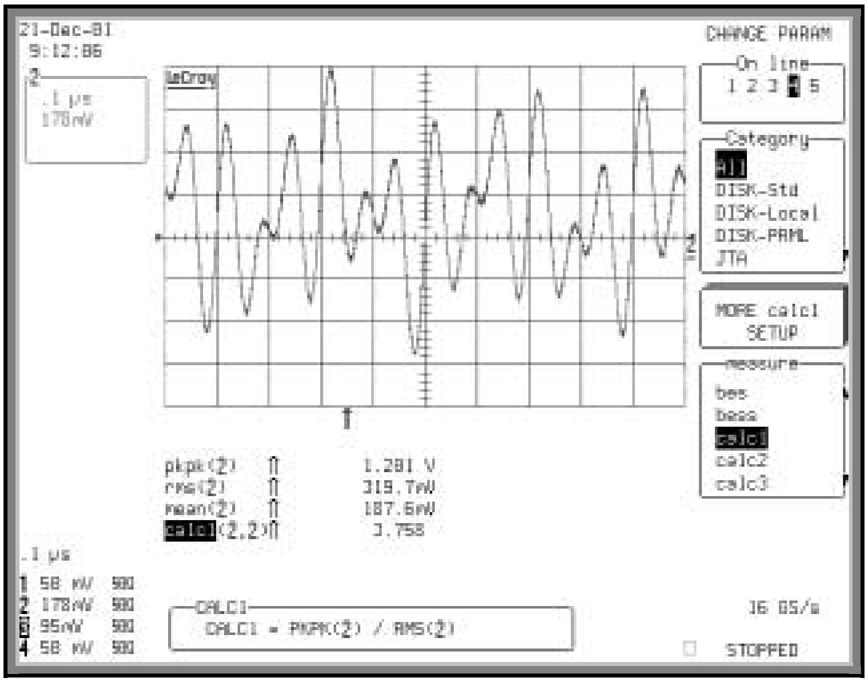


Figure 1.7. Calculated parameters allow the creation of custom parameters. Here calc1 is set up to measure crest factor (peak-to-peak/ rms).

Selecting the calculated parameter **calc1** from the "measure" parameter menu allows you to set it up, as shown in Figure 1.8. Here the parameters, source waveforms, and arithmetic operator can be selected. The calc1 parameter has been set up to display the ratio of peak-to-peak to rms for channel 2. This is shown in the "calc1" summary box under the grid.

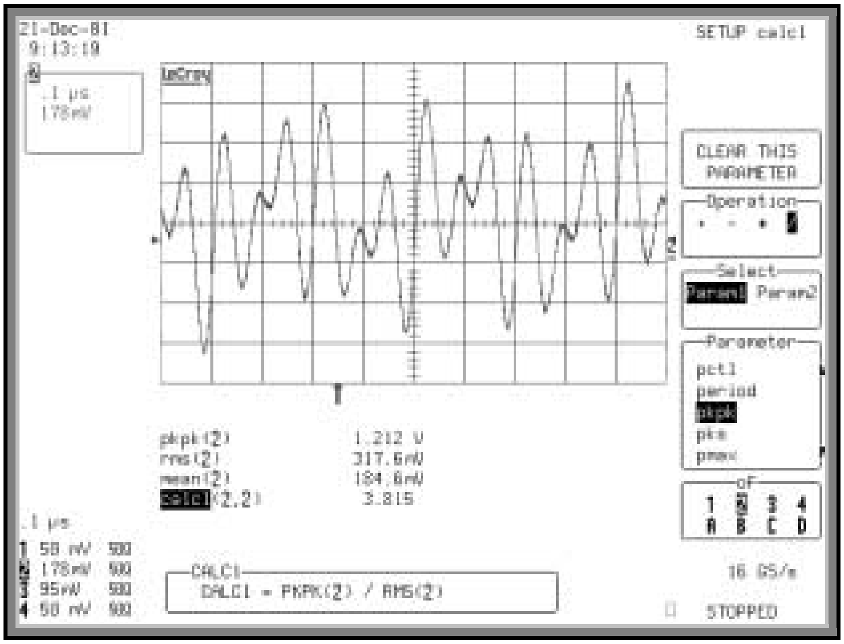


Figure 1.8. Defining Calc1 to Read the Crest Factor of Channel 2

The five calculated parameters compute new parameters based on any two parameters operating on any combination of the acquisition channels or math/zoom traces. The source parameters do not have to be displayed.

Figure 1.9 is an example of setting up a direct measurement of the modulation index of an FM signal. Phase modulation has been performed using the JitterTrack™ of time interval error (TIE) of the input signal from channel 2. Differentiation and rescaling convert the TIE function into the demodulated FM signal. The TIE function is multiplied by the carrier frequency of 400 MHz. This results in a display of frequency deviation versus time. Because the ratio of $^1/_2$ the peak-to-peak frequency deviation is required for the FM modulation index, TIE must also be divided by 2. All this is done in Trace D, using the rescale function to multiply by $2{*}E^8$ (400 MHz/2). In general, all additive or multiplicative constant operations in the calculated parameters require the rescale function. (In this example the rescale operation was required anyway.)

Figure 1.10 shows the setup of calculated parameter **calc5** to read the FM modulation index by taking $^1/_2$ the peak-to-peak frequency deviation divided by the modulation frequency. Both parameters are derived from trace D.

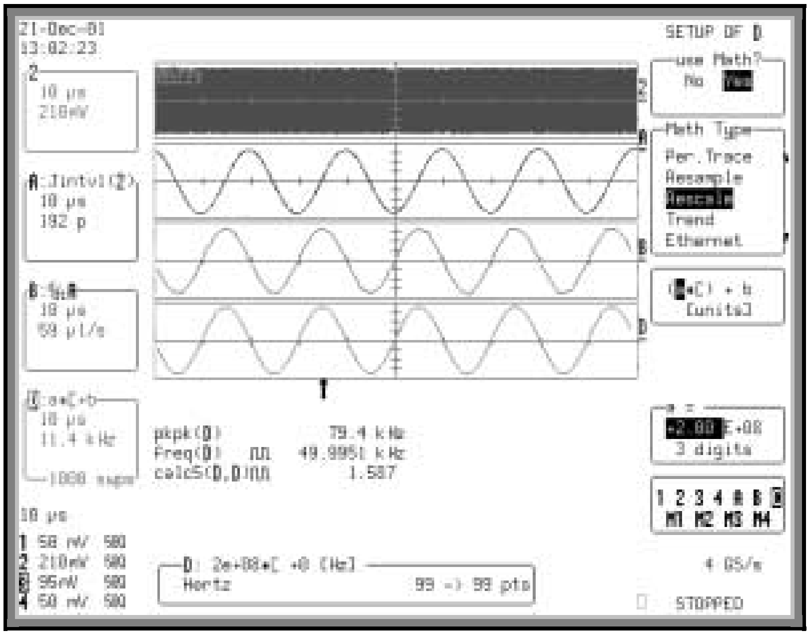


Figure 1.9. Using Rescaling to Convert TIE to a Display of Frequency Deviation

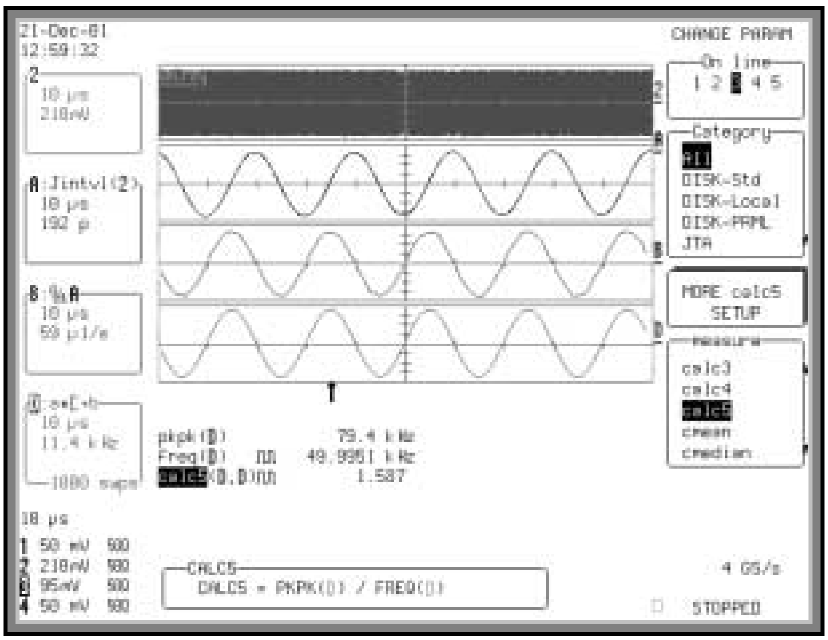


Figure 1.10. Setting Calc5 to Measure FM Modulation Index

LOGARITHMIC PARAMETERS

The Parameter Math option prevents multiplication and division of parameters that return logarithmic values. These parameters are as follows:

- auto-correlation signal-to-noise ratio (ACSN)
- narrow-band power (NBPW)
- media signal-to-noise ratio (MSNR)
- residual signal-to-noise ratio (RSNR)
- top-to-base ratio when the units are in dB (TBR)

EXCLUDED PARAMETERS

Parameters that are already the result of parameter math operations are excluded, and will not appear in the parameter menu. If they are included in a remote control setup command, an error message is generated and the setup canceled.

- Excluded parameters are as follows:
- beginning edge shift (BES)
- beginning edge shift – list (BES)
- beginning edge shift sigma (BESS)
- beginning edge shift sigma – list (BESS)
- delta clock-to-data near (DC2D)
- delta clock-to-data next (DC2DPOS)
- delta clock-to-data previous (DC2DNEG)
- delta delay (DDLY)
- delta pit-to-clock (DP2C)
- delta pit-to-clock – list (DP2C)
- delta pit-to-clock sigma (DP2CS)
- delta pit-to-clock sigma – list (DP2CS)
- delta time at level (DTLEV)
- end edge shift (EES)
- end edge shift – list (EES)
- end edge shift sigma (EESS)
- end edge shift sigma – list (EESS)
- phase (PHASE)
- resolution (RES)
- apparent power (APWR)
- mTnTmT shift (BEES)
- mTnTmT shift sigma (BEESS)
- mTnTmT shift sigma – list (BEESS)
- power factor (PF)
- real power (RPWR)

TO SET UP PARAMETER MATH

1. Press **MEASURE TOOLS**.
2. Press the button for "Parameters." The MEASURE menu panel appears.
3. From the "mode" menu, select **Custom**.
4. Press the button for "Change Parameters." The CHANGE PARAM menu panel appears.
5. From the "On line" menu, select the line (**1** through **5**) below the grid on which you want to show the calculation result.
6. From the "Category" menu, select **All**.
7. From the "measure" menu select, **calc***x* (**calc1** through **calc5**).
8. Press the button for "More Calc*x* Setup." The SETUP CALC*x* menu panel appears.
9. If the current calc parameter is already defined and you want to redefine it, press the button for "CLEAR THIS PARAMETER."
10. From the "Operation" menu, select an arithmetic operator (**+**, **–**, *****, **/**).
11. To set the first parameter in the equation, select **Param1** from the "Select" menu. Then choose a parameter from the "Parameter" menu.
12. Set the second parameter in the equation by selecting **Parm2** from the "Select" menu. Then choose a parameter from the "Parameter" menu.

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