Agilent PN 89400-10

Time-Capture Capabilities of the Agilent 89400 Series Vector Signal Analyzers

Product Note

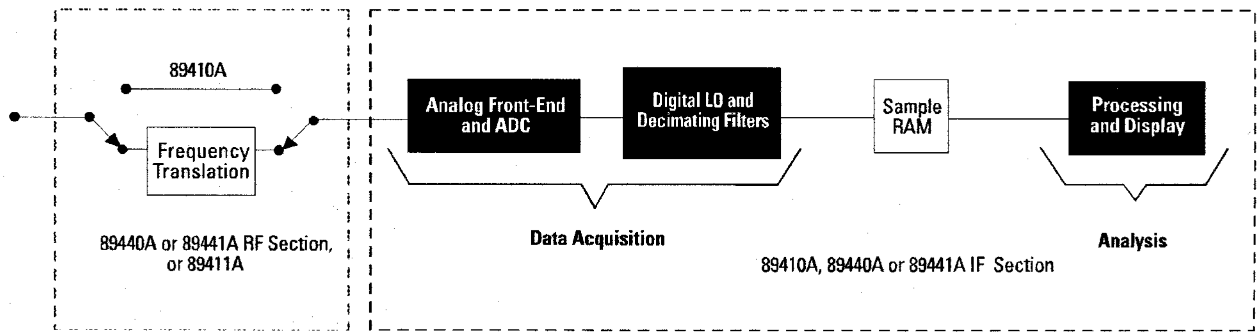

Figure 1. Simplified block diagram showing basic signal flow in the Agilent 89400 Series VSAs

Introduction

When measuring a burst communications transmission or other nonstationary signal, it is often necessary to observe or analyze the signal for a significant period of time to adequately characterize it. The Agilent Technologies 89400 Series vector signal analyzers (VSAs) feature a time-capture capability that enables the user to collect up to 1 Msample of data at a time and later choose what type of analysis to perform on the data.

Measurements can be done in one of two ways: *measure from input* and *time capture*. When using measure from input, the instrument collects a block or record of samples and performs the analysis immediately. This analysis may involve performing an FFT, demodulation, or averaging. When using time capture, the instrument collects a (possibly) much larger number of samples and stores them to memory, but does not perform the analysis immediately. Instead, the user can choose the type of analysis to be performed at a later time.

To understand how time-capture works in the 89400 Series VSAs, refer to the instrument block diagram in Figure 1. The process involves two principal events: data acquisition and analysis. During data acquisition the signal is conditioned, sampled, and converted into a stream of digital values that are stored in the sample RAM. During analysis, a coordinate transform is applied to the digital values and the data is scaled for display.

The ability to perform signal analysis separately from signal acquisition gives the user some significant advantages. Foremost is the ability to analyze the signal in many different ways after the data has been collected. Another advantage is that the data record has no gaps in it. The instrument collects the data in one time-continuous block. (When using measure from input, there is a short period of time when the analysis is being performed on the time record that has just been collected. While this period of time is small, there still may be some data missed.)

The remainder of this paper describes setting up time-capture measurements, and looks at how to exploit this flexible analysis capability to its fullest. In addition, there's an overview on how to save and recall captured data from a mass storage device, and how to transfer data to an external computer for additional analysis.

Acquiring time-capture data

Time capture is critical when you wish to measure a signal that will only be present once and/or whose exact characteristics aren't known in advance; however, you do need some basic knowledge of the signal's characteristics before you start the time-capture procedure.

To initiate the instrument for time capture:

Set the instrument mode to Vector

The choice of instrument mode affects the way the instrument collects the data, and how it can be viewed or analyzed later. It is not possible to perform time capture in Scalar mode. After the data collection is complete, you can choose between Vector and Demodulation modes depending on how you would like to view the data.

Set the correct receiver

Make note of your choice of receiver (RF, IF, external, or ch1+j*ch2) when you save time-capture data. You must set the instrument to the same receiver to analyze the time-capture data as it was when the data was originally collected. You can examine the data and the header information by using the Structured Data Format (SDF) utilities provided with the instrument.

Set the center frequency and span

The frequency span should be as narrow as possible while still including all the important components of your signal. This prevents unwanted signals from corrupting the measurement and also allows the collection of the longest possible time record.

The 89400 Series VSAs offer unique versatility in their ability to implement arbitrary frequency spans and resolution bandwidths, which has implications when making time-capture measurements. To obtain the longest time capture for the range of frequencies you wish to capture, set the frequency span to a value that can be represented as 10 MHz/2^N, where N is an integer. This is often referred to as a cardinal span. By using the up/ down keys the instrument will usually select the nearest "nice" value (often divisible by a power of ten), or the nearest cardinal value. If you set the frequency span to a value that is not a cardinal span, the instrument will use the sample rate appropriate for the next larger cardinal span, consuming a larger amount of sample RAM. For example, if you chose a 5.1 MHz span, the instrument will collect data at the same rate as if you had set a 10 MHz span.

If you plan on performing digital demodulation analysis (Option AYA) on the time-capture data, use the following formula to determine the maximum span:

$$\textbf{Maximum span (digital demod)} = \frac{\textbf{20 * [symbol rate]}}{\textbf{k}}$$

where: k = 2.56 if the receiver is [ch1 = j*ch2], k = 1.28 for all other receivers.

Table 1. 89400 Series VSAs Standard Configuration with 64k of Time-Capture Memory

	One Channel Instrument		Two Channel Instrument	
	Baseband Measurement	Zoomed Measurement	Baseband Measurement	Zoomed Measurement
Maximum Number of Sample Points*	65,536	65,536	32,768	32,768
Maximum Time Length	2.56 ms	5.12 ms	1.28 ms	2.56 ms

89400 Series VSAs With 1-Meg Extended Time-Capture Memory (Option AY9)

	One Channel Instrument		Two Channel Instrument	
	Baseband Measurement	Zoomed Measurement	Baseband Measurement	Zoomed Measurement
Maximum Number of Sample Points*	1,047,552	1,048,064	523,264	523,776
Maximum Time Length	40.92 ms	81.88 ms	20.44 ms	40.92 ms

* The maximum number of points will be less if you use an arbitrary span. For Option AY9, the maximum number of points varies slightly with changes in the number of frequency points selected. The values in this table were obtained with the number of frequency points set to 401.

Set the trigger and input configuration
To capture a transient event, IF triggering often provides the best results, since the instrument will only start collecting data once a signal appears in your frequency span. You can also set a negative trigger delay to capture time before the trigger event, much as you might do with an oscilloscope.

Set the source type and level
If your measurement requires the 89400 Series VSAs internal source as a stimulus, set the source type and level.

Set the input channel(s)
For the signal you are capturing set the input channel(s) to the proper range and impedance. Turn off the second input channel if you don't need it (see the Input hardkey). This allows the instrument to use all of the capture RAM for channel 1.

Specify the amount of data to be captured
The amount of data captured can be specified in units of time, number of records, or number of sample points. Often you will want to know the longest time or largest number of sample points that can be collected. This depends on instrument setup, as mentioned above, and on the size of the sample RAM available. The capacity of the time-capture buffer also depends on whether a baseband or zoomed measurement is being made. For a baseband measurement, the selected span starts at exactly zero Hz, while in general, a zoomed measurement covers a frequency span which does not include zero Hz. Table 1 shows the maximum amount of data which can be captured for several instrument configurations.

There are two ways to think about the capacity of the sample RAM. In this product note we will often refer to the size of the sample RAM, and the length of the time capture. The size refers to the number of samples the instrument will collect, while the length is the amount of time over which the capture took place. The length is simply the number of samples collected multiplied by the time between samples.

The number of samples to be collected is under the user's control and can range from 512 to 64k (standard instrument) or 1 Meg (Option AY9 extended time capture). The time between samples is inversely related to the frequency span and can take on a wide range of values, from as short as about 40 ns to almost 1 second. The resulting range of time-capture lengths extends from a few microseconds to several thousand seconds. This capability allows measurement of events such as the first few milliseconds during the turn-on of a mobile radio to the long-term drift of a relatively stable VCO. Figure 2 illustrates the inverse relationship between the frequency span, the sample rate, and the measurement record length. A large extent or length in the time data yields a measurement with a narrower frequency span while finer time resolution and a shorter time length yields a wider frequency span.

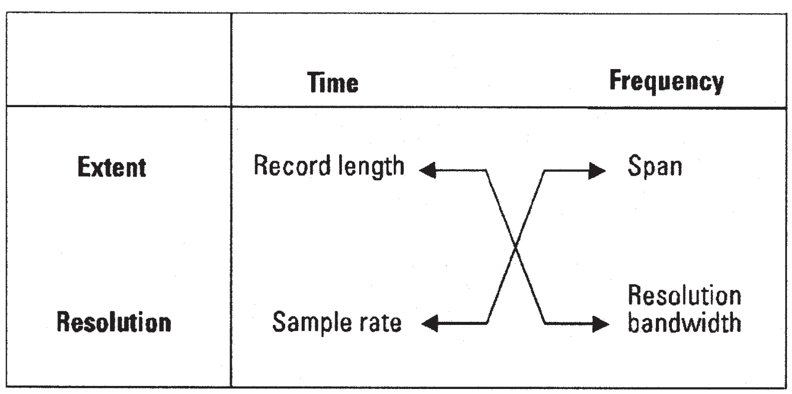

Figure 2. Some measurements have both time-domain and frequency-domain aspects. Because of the nature of the fast Fourier transform, these two aspects are not independent. The extent and resolution of the time and frequency data are interrelated as shown here.

Performing the capture

To perform time capture, simply press the [fill buffer] softkey. This key is reached by pressing [Instrument mode] and then [capture setup]. The instrument display will not update during the capture; data is only being collected at this point. When it is finished, a message will appear on the display indicating the length of time over which the capture took place.

Once the capture is completed you can view the number of bytes of data collected, block size, and other parameters the instrument generates to describe the organization of the data in the capture buffer. To get to this display press [Instrument Mode], [capture setup], [buffer info on]. It's a good idea to do a trial time-capture measurement to ensure the triggering is set up correctly and that the sample rate and number of samples were quantized by the instrument to the values expected.

Analyzing the captured data

After the capture is complete, you can view the data by pressing the [Meas Restart] hardkey. You can control the analysis to be performed on the data by changing the following parameters:

- Instrument mode (demodulate the data, or view it in vector mode)
- Analysis region (the portion of the capture buffer to analyze)
- Resolution bandwidth
- Averaging
- Windowing
- Measurement data type (time, power spectrum ...)
- Data format (magnitude, phase, group delay ...)
- Gating

Examining your signal in more detail with Overlap Processing

Occasionally when playing back captured data of short time duration (i.e., one made with a high sample rate), the buffer is displayed very quickly. There are two ways you can slow the "playback" of captured data to better view the details of your signal: by individually stepping through each record, or by using a feature of the Agilent 89400 Series VSAs called overlap processing.

To inspect the time-capture buffer a record at a time, switch the sweep mode to single and press the [Pause/Single] key. Each keypress allows the next record in the buffer to be processed and displayed. By setting the [analysis region] (under the [capture setup] softkey), you can view a selected portion of the buffer. (By default, the analysis region includes the entire capture buffer.)

With overlap processing, the instrument pulls less than a full time record from the time-capture buffer for processing and display. (Under the [Time] hardkey the amount of overlap for averaged and non-averaged measurements can be specified.) When overlap processing is enabled, the display represents data calculated partly from the current time record and partly from the next time record.

The percent overlap parameter sets the amount of the current time record used. For example, if 90% overlap is specified, 90% of the samples come from the time record used to calculate the current display and 10% of the samples contain new data from the next time record in the time capture buffer. If you set the overlap percentage to zero, the data is played back from the capture buffer as fast as possible and each display update reflects entirely new data.

This capability provides a way to view rapidly changing, complex signals. You can use overlap processing in combination with single sweep mode, or with the spectrogram or waterfall displays (Option AYB). To view the contents of the buffer in reverse, change the direction of the capture playback under the [analysis region] softkey.

Other time-capture considerations

While you cannot playback captured data through the baseband source, (you may want to do this to stimulate a circuit with a signal identical to one you have measured previously), the source can playback data from one of the data registers, and these data registers can contain data saved from one of the time records in the time-capture buffer.

One important point to keep in mind: switching the instrument from time capture back to measure from input erases all previously collected time-capture data. You will also lose the time-capture data if you preset the instrument, change receivers, or recall an instrument state file from mass storage, since this performs an implicit instrument preset.

Saving and recalling time-capture data

You can store time-capture data to any available mass storage unit, (internal or external disk, volatile or nonvolatile RAM disks). Before storing a time-capture file, make sure the mass storage unit you've chosen has enough free space to save the entire file. Although the instrument allows you to split a file across multiple disks if there is not enough room, it is more convenient and faster if the file fits completely on one disk. You can estimate the file size before you try to store it from the number of sample points chosen. For a baseband measurement, the file size in bytes will be about 4 times the number of sample points, while a zoomed measurement will take about 8 times the number of sample points.

There is additional information stored in a header with the time-capture data, which helps the instrument interpret and analyze the data. Frequency limits, correction data, and other instrument parameters are stored in this header.

Captured data can also be transferred from the instrument to an external computer via GPIB or the LAN interface if the instrument has option UFG (4-MBytes extended RAM and additional 10) installed. The data format for time-capture data is the same as for trace data, but again the amount of data transferred can be much larger. You may have to take special steps to insure your program has enough memory available to store all the data.

Once in an external computer, use the SDF utilities to examine or manipulate the data. The data can also be translated into the formats used by a number of popular analysis programs such as MATLAB from The Math Works and $MATRIX_X$ from Integrated Systems.

Time-capture data is recalled from a storage device as you would recall other stored trace data. Note that when you recall time-capture data the instrument state is modified to match the state of the instrument when the time capture took place.

A time-capture measurement

To illustrate the insight provided by the time-capture capability of the Agilent 89400 Series VSAs, a measurement example is presented that uses many of the techniques discussed here. The signal of interest is the output of a synthesized signal generator during a frequency sweep. Signal sources like this are often used as a stimulus in network-analysis measurements. Typically, this type of signal generator employs a synthesis scheme involving multiple phase-locked loops and often generates significant frequency transients as the loop(s) divider values change while sweeping. To investigate these transients, we captured a portion of the generator's sweep and then displayed it with two different scales and overlap processing on a spectrogram display.

The spectrogram display (Option AYB) is used to simultaneously show the signal's amplitude and frequency versus time. The signal's amplitude is represented by intensity or color, while the changes in the spectrum over time are represented by scrolling information up the display from the bottom. The x-axis represents frequency, as in other spectrum displays. As shown in Figure 3, the signal's frequency increases during the measurement, and except for the transient in question, remains at a relatively constant amplitude (constant intensity on the display) throughout. To make this measurement, we configured the 89440A (dc to 1.8 GHz) in Vector mode with a center frequency of about 24.5 MHz, and a frequency span of 625 kHz. We set a capture buffer size of 65,536 points, and since this is a zoomed measurement, the resulting time length is 81.92 ms. This is the maximum number of time points available when the instrument is configured to measure only one channel. (See Table 1.) IF trigger and negative trigger delay were also used.

At this scale, the sweep has covered about 200 kHz and the transient seems rather innocuous, it is just a narrow line across the display, indicating the signal went through a large but very quick frequency excursion. To see the full extent of this frequency transient, and the amplitude perturbation that may have occurred at the same time, the overlap was increased to 80 percent, the result is shown in Figure 4. You will find, as we did here, that you need to experiment with the amount of overlap, using the value which produces the most intuitive picture on the display.

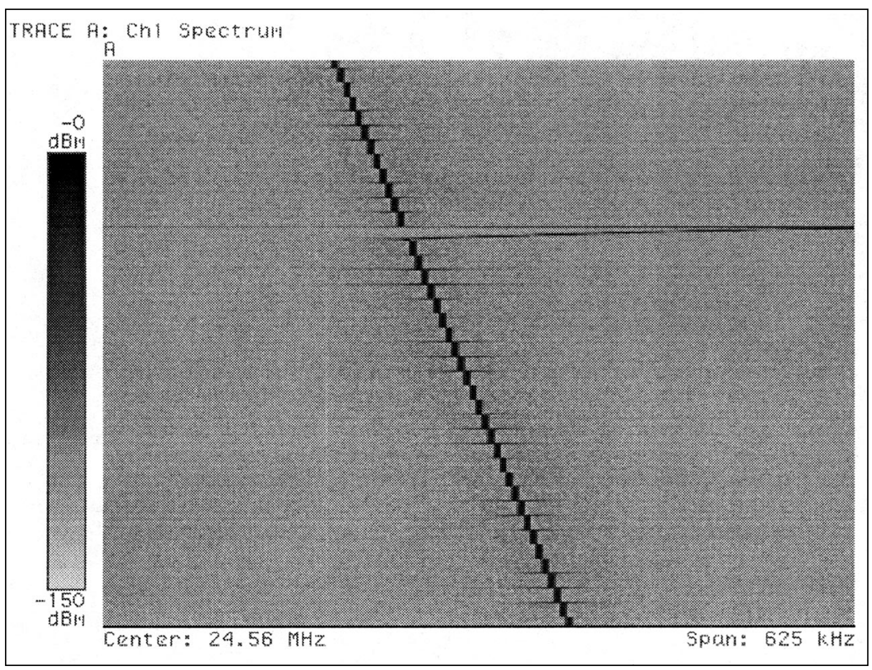

Figure 3. Spectrogram display showing a transient during the frequency sweep produced by a synthesized signal generator

Figure 4 shows that the frequency deviated by at least 300 kHz during the transient, both above and below the original center frequency. By using markers (not shown here), the decay time of the transient was determined to be about 15 ms. Other features of this transient are also visible at this scale. For example, there seems to be some noise on the signal during the decay period of the transient. And, by looking carefully at the signal after the transient has ended, we can see sidebands which appear to be spaced about 20 kHz apart and which take at least 50 ms to completely decay. Other periodic but smaller transients are also visible after the main transient has decayed.

If this source was part of a network measurement described earlier, the device under test might not respond in a linear fashion to this type of frequency transient. The measured response from this kind of stimulus would probably be invalid.

Conclusion

The advantages of time capture in the Agilent 89400 Series VSAs include:

- Post-measurement analysis
- Versatile analytical tools for complete signal characterization and elimination of data gaps
- Overlap processing with "slow motion" capability for easier analysis of rapidly changing complex signals.

For additional information on the use of time capture, see Agilent Product Note 89400-5, *Measuring Transmitter Measurements with the Agilent 89400 Series Vector Signal Analyzers,* and the sections of the 89400 Series VSA data sheets describing waterfall and spectrogram displays (Option AYB).

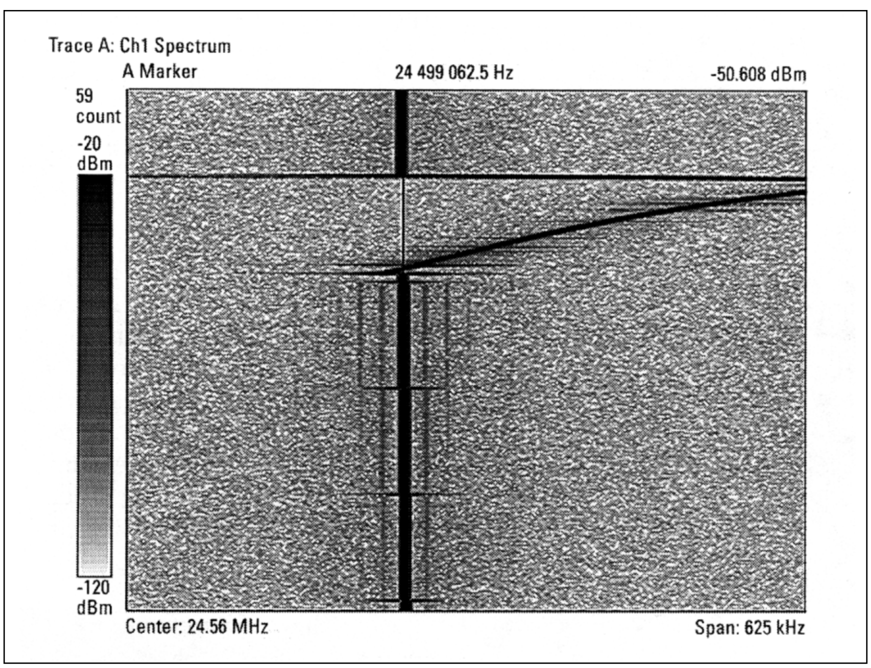

Figure 4. Same signal as shown in Figure 3 with a larger amount of overlap processing

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