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Narrow-Bandwidth Sweep Gating --*Time-gated spectrum analysis with the HP 3589A*

In many applications the signals used to convey information or make measurements are a series of bursts. These signals can be found in rotating magnetic and optical storage systems such as VCRs and optical disk drives, medical and industrial ultrasound applications, and optoelectronic equipment. In addition, new applications using burst signals are continually emerging, as seen in time-division multiple-access communications systems, and frequency and amplitude modulated digital transmission.

Designing or testing systems that use burst signals can be difficult. Traditional spectrum analysis, which has proven to be useful for making noise, distortion, amplitude, and signal purity measurements in continuous wave environments, is not sufficient to characterize these burst systems.

The HP 3589A spectrum/network analyzer with time-gated spectrum analysis option 1D6 provides time-selective spectrum analysis by sweep gating. Using this capability, you can characterize only the portion of the burst signal you want and achieve the benefits of spectrum analysis to make noise, distortion, amplitude, and signal purity measurements.

This paper describes sweep gating as implemented in the HP 3589A. In some cases it also compares sweep gating to video gating methods which may be used in analyzers with local oscillators (LOs) that cannot be stopped and restarted easily.

Delay and gate length range:

A spectrum analyzer's resolution bandwidth (RBW) establishes most of the time-domain parameters for selective spectrum analysis (see figure 1). In general, to look at shorter bursts requires wider RBW filters that have faster settling times.

The digital IF developed for the HP 3589A provides excellent narrow resolution and accuracy at the fastest speed possible. With this performance, wide resolution bandwidths are not required to maintain fast sweeps. In the widest resolution, the HP 3589A requires a minimum set-up time of 130 microseconds and the minimum gate length is 20 microseconds. Thus accurate noise and amplitude measurements require a stable pulse of at least 150 microseconds. Small reductions in delay can often be made and will have little effect in amplitude accuracy, but the noise floor will be degraded.

Glossary

Delay - The total time from the gate trigger event to the beginning of the open gate window. If the trigger is concurrent with the pulse, then the delay equals the set-up time. This value is programmable in both edge and level triggered gating.

Edge triggering - When the gate opening is established by the trigger edge event and the delay and gate length are programmed.

Gate length - The time that the gate window is open. It is programmable using edge triggering, or, for level triggering, is established by the delay and the end of the active trigger.

Level triggering - When the gate opening is established by the active trigger level and the delay time is programmed.

PRI - The pulse repetition interval or time between the bursts. For non-periodic pulse trains, the longest possible interval should be considered.

Set-up time - The filter settling time required before the gate is open. This time is established by the RBW and also the VBW, but in general, the minimum recommended time is 2/RBW to allow the best dynamic range and accuracy.

Signal delay - The time from the gate trigger event to the beginning of the pulse. If the trigger is concurrent with the pulse, the signal delay is zero.

Sweep gating - A method for time-selective spectrum analysis where the LO is only sweeping when the gate is open. This scheme requires an LO that can be stopped and restarted easily.

Video gating - A method for time-selective spectrum analysis where the measurement data is only displayed when the gate is open. This scheme may be used when the LO sweep is not fully controlled and cannot be stopped and restarted easily.

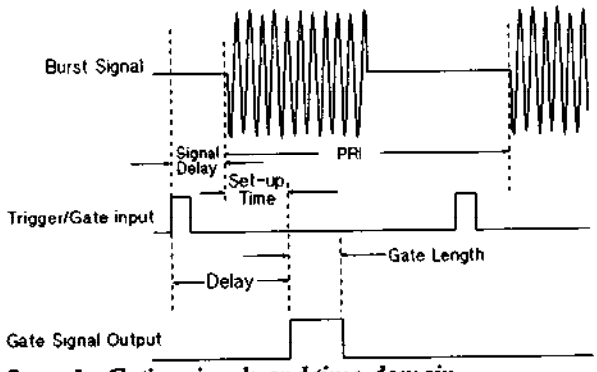

figure 1 - Gating signals and time-domain parameters.

For applications such as rotating media and head testing, some time-division multiple-access communications, MRI, and ultrasonics measurements, this length is sufficient for complete characterization.

Noise measurements:

Some applications, such as magnetic media and head testing, require signal-to-noise ratio measurements. Since the tracks are divided into sectors or the heads are rotating, the signals are seen as a series of bursts. These signal-to-noise ratio measurements calls for techniques such as sweep gating.

An important benefit of sweep gating in the HP 3589A is the ability to make accurate noise measurements in the presence of burst signals. All of the analyzer's noise measurement features work with gating. These features include a noise marker, for accurately measuring the noise at a single frequency point, and trace math, for automatic normalization of an entire noise trace to 1 Hz or any other desired bandwidth.

Accurate noise measurements usually require some form of filtering or averaging to reduce the noise variance. Analyzers that use video bandwidth (VBW) to reduce the variance can run into the same gate length and delay length limitations that were described for RBW. The HP 3589A, however, performs trace averaging that can be used while gating to reduce the noise variance without affecting the settling characteristics.

Measurement times:

Significant differences in measurement times exist between video gating and sweep gating methods. To obtain accurate results using video gating, characteristics of the burst signal must be known. To ensure results at every point, the analyzer sweep time must be longer than (n*PRI), where n is the number of frequency points and PRI is the longest pulse repetition interval.

Less knowledge of the signal is necessary with the sweep gating option of the HP 3589A. Since the analyzer is sweeping only during the gate window established by the trigger conditions, no sweep time calculation based on the PRI is necessary. And, since more than one frequency point can be acquired during each gate, faster measurements are usually possible than with video gating.

For example, consider a 2 msec burst with a 33 msec PRI and 400 frequency points spanning 4 MHz displayed on the spectrum analyzer. The minimum sweep time will be 12 seconds to guarantee accurate results at each point using video gating. With the HP 3589A, however, the measurement time will be less than 0.2 seconds in the widest resolution bandwidth and with oversweep on.

Component characterization:

The HP 3589A spectrum/network analyzer also offers sweep gating capabilities with network measurements. This is useful for measuring components operating in a time-multiplexed system. During the periods when the device or system is not active, tests can be performed to monitor degradation and provide information that can be used to prevent a serious system failure.

Programmable gate parameters:

Sweep gating in the HP 3589A is provided with features that make it easy to use. Edge triggering, along with the programmable delay and gate length, provides automatic time gating control. Level triggering with a programmable gate delay requires the external trigger signal to control the gate length.

Setting up the measurement is easy using the gate signal output on the rear panel. Supplying this signal and the burst signal to a dual-channel oscilloscope will display signals similar to the top and bottom traces of figure 1, confirming that the gate window is where you want it.

The HP 3589A is a high-performance analyzer with excellent narrow resolution and speed. With sweep gating to provide complete noise analysis, component characterization and easy operation with fast measurements, the full benefits of spectrum analysis can be used to characterize many different systems that have burst signals.

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