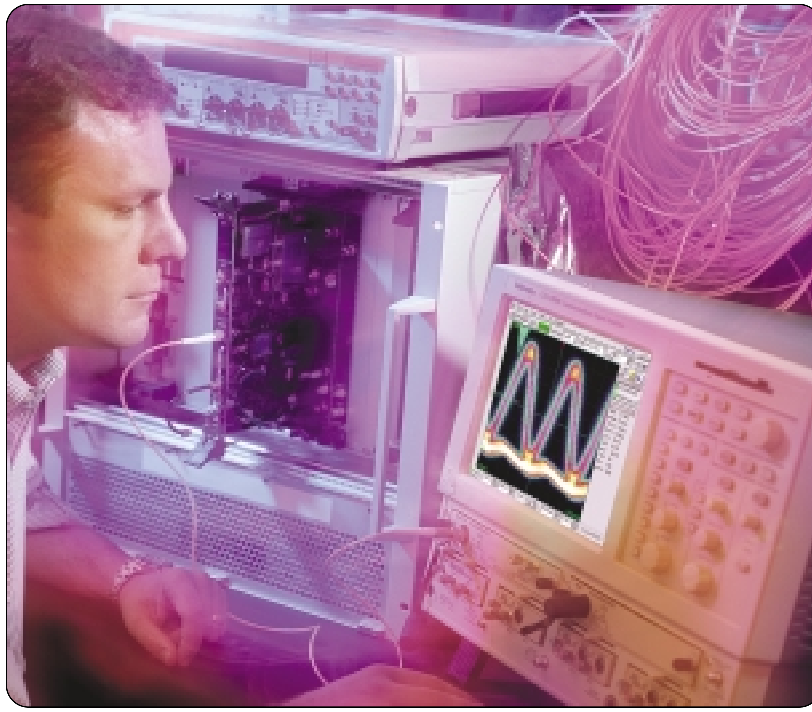

Circulating Buffer Testing Using the CSA8000B's Gated Trigger Function

Simulating Long Links: Fast Acquisition Rates Reduce Test TIme

Suppliers of network equipment and fiber optic cabling need to characterize the attenuation and dispersion characteristics of very long fiber optic links. These long links can be simulated by looking at the effects of propagating a test signal through multiple circulations of a shorter length of fiber. The Tektronix CSA8000B's 150 Ksample/sec data rate significantly reduces capture time, saving money and adding convenience.

With the increasing demand for bandwidth, driven by the Internet explosion of the past several years, network operating companies are looking to increase the effective bandwidth of their fiber plants as well as the distances that links in their networks can span. It is not unusual for these companies to be looking to provide links several thousands of kilometers in length. This is true for both undersea and terrestrial links.

While it is necessary to validate the actual deployed solution, many vendors of network equipment and fiber optic cabling companies have expressed a desire to simulate very long links by looking at the effects of propagating a test signal through multiple circulations of a shorter length of fiber. For example, routing a signal 20 times through a loop of fiber 500 km in length can simulate a 10,000 km trans-oceanic fiber link.

In order to view such a signal, one would typically use a high-bandwidth sampling oscilloscope. When used to examine a signal propagating through a circulating loop such as that described above, the instrument should only sample the data elements that have propagated the correct number of times through the loop. Therefore, the sampling oscilloscope needs to be synchronized with the signals used to control the loading and circulation of data within the loop. In addition, the sampling oscilloscope needs to have a high acquisition rate to make the tests cost effective.

Given that high-bandwidth sampling oscilloscopes acquire data using sequential equivalent-time sampling, one of two conditions must be satisfied in order to produce a stable display of waveform data.

1. The acquired signal must be repetitive and triggered on a signal synchronous to the input signal
2. The acquired signals must have a fixed clock rate and be triggered on a signal that is synchronous to that rate

Signals that are acquired using the first triggering scheme are deterministic in nature. Therefore, users can examine the wave shape of specific data bits within the repetitive pattern as well as pattern-dependent effects such as inter-symbol interference.

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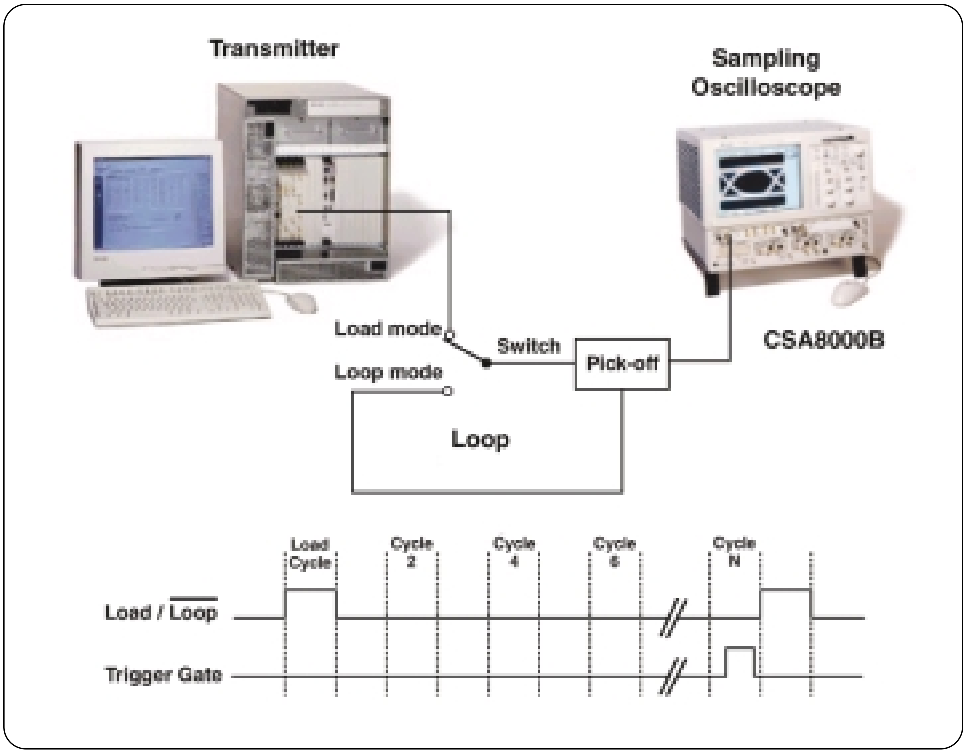


Figure 1. *Timing diagram for N-loop recirculating buffer.*

Signals acquired using the second methodology are random in nature and will display as an “eye diagram.” Measurements on eye diagrams can provide valuable statistical information on the behavior of the device-under-test for a wide variety of patterns. Specific pattern dependent effects are masked and therefore not discernible from signals acquired in this fashion.

In either case, the sampling oscilloscope acquires a single data point per trigger. To acquire a 500-point waveform record, the sampling oscilloscope must respond to 500 separate trigger events. The Tektronix CSA8000B Communications Signal Analyzer has a trigger gate function with an external TTL compatible Trigger Gate BNC connector. With the trigger gate feature enabled, a high TTL signal level at the port enables the oscilloscope to respond to trigger edges and thus acquire data. When the signal at the port is low, the CSA8000B will not respond to triggers even if they are present; they are simply ignored and waveform data is not captured.

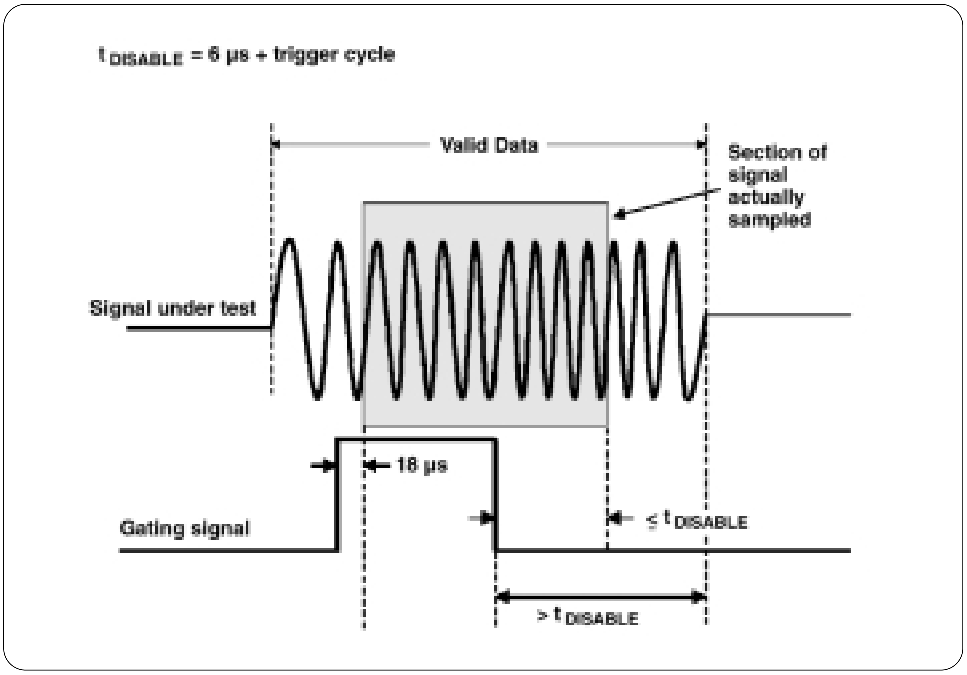
An example of the control signals used in a circulating loop experiment is shown in Figure 1. The basic process is to configure the switching to load the loop with data, and then close the loop so that the data continuously propagates. Once the data has traversed the loop the correct number of times, the CSA8000B is gated to allow it to respond to the trigger signal and acquire only the desired portion of data. It is important to note that the signals used to control the loop switches, as well as the signal used to gate the oscilloscope, are defined and provided by the user. The oscilloscope itself does not generate or control any of these signals.

Trigger Gate Timing Considerations

The exact timing required for loading the loop and circulating within the loop is determined by the propagation time to complete the number of circulations required. It is ideal to have the duration of the trigger gate enable signal be less than the round trip time through the loop. This is necessary to guarantee that any signals acquired are temporally distant and within the time between the switching transients as well as to allow for the delay required to enable and disable the oscilloscope gating. In the example mentioned above, the 500-km loop has a round trip time of about 2.5 ms. The trigger gate should be set to about 1.5 ms in duration to avoid the switching transients. The gating pulse is enabled only after 20 round trips through the loop, so the gating function and load/loop switch should have a period of 50 ms.

If an experiment is to be conducted which requires a greater level of precision in controlling when the gate is enabled and disabled, it becomes important to consider the rate at which the instrument responds to both the enable and disable states of the gating signal. Generally when considering the enable time for the gating signal, the trigger gate and the trigger signal can be asynchronous. In order to avoid metastability conditions, the instrument discards the first three points that it acquires following the enable signal. The instrument is able to acquire valid data approximately 18 µs after the gate is enabled (low-to-high transition).

When the gating signal makes the high-to-low transition, the oscilloscope will not respond to trigger signals. In the sampling process, the oscilloscope is triggered and a sample is taken at a time equal to the delay setting (minimum of 19 ns). Once a sample is taken, the oscilloscope must re-arm. This takes approximately 6 µs. In the process of re-arming, the status of the trigger gate port is checked. Thus, if the gate goes from a high-to-low just after the status is checked, more than 6 µs will elapse before the instrument will no longer accept triggers. The maximum time that can elapse from the time a trigger is accepted, the gating signal drops from high-to-low, and a data sample is taken is defined by $t_{DISABLE}$ = 6 µs + trigger cycle (where the trigger cycle can be affected by the actual frequency of the trigger signal as well as the trigger hold-off specified by the user. The trigger enable and disable timing is shown in Figure 2.



▶ ***Figure 2.*** *Trigger gating – Enable / disable timing considerations.*

Additional Considerations

In many instances, the propagation time through the circulating buffer will be shorter than the time required to capture a complete waveform. In the case of the CSA8000B, the typical waveform acquisition rate is 150 Ksamples/sec. Thus, it will take >3.3 ms to acquire a complete 500-point record. In the previous example, the loop time was 2.5 ms. In order to assure that the data sampled was well away from any transients, it was suggested that the trigger gate only be active for 1.5 ms. To acquire one full 500-point waveform requires three cycles of the test setup. In order to accommodate this multi-cycle acquisition requirement when the trigger gate signal is disabled (transitions from a high-to-low), the CSA8000B does not continue to accept triggers until the waveform record is complete. Rather, it “pauses” the acquisition and waits for the next trigger gate enable transition. After a little more than two cycles, a complete waveform is acquired. Without this pause/resume acquisition feature, the minimum buffer loop time that could be accommodated would be >4 ms. For our example experiment, this equates to a minimum fiber loop of nearly 1000 km.

Industry Leading Data Capture Rate Reduces Test Time by a Factor of Five

One final consideration when choosing equipment to use for circulating loop testing is the amount of test time required to acquire a statistically valid data sample. As stated earlier, the CSA8000B acquires data at typical data rates exceeding 150 Ksamples/sec. For our example experiment, the total test loop time was shown to be 50 ms. As shown above, the CSA8000B would require 2.25 cycles of the test loop to acquire a single 500-point waveform. This equates to approximately 120 ms per waveform. A statistically valid data set might consist of 500 waveforms. Therefore with the CSA8000B, it would take about 60 seconds to acquire a statistically valid set of waveforms. Alternative solutions have acquisition rates one fifth that of the CSA8000B and would require more than five minutes to acquire the same amount of data.

CSA8000B

The CSA8000B's industry leading acquisition rates provide a solution for simulating long links cost effectively and in significantly less time than ever before.

OTS Product Family

The OTS Product Family offers flexible testing capabilities designed to concurrently support multiple tests. It features three different chassis designs and multiple testing modules, which can be used interchangeably in all chassis.

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