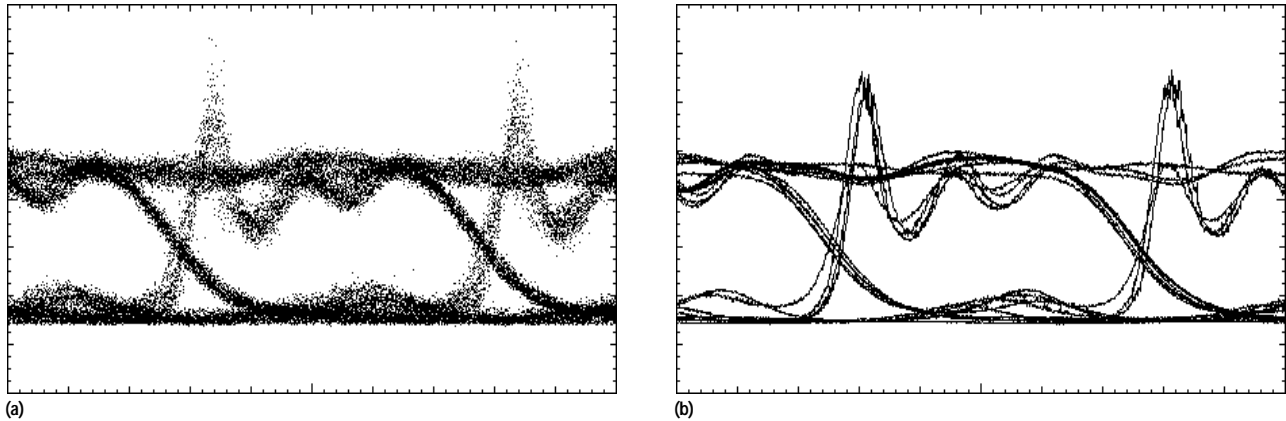


# HP Eyeline Display Mode

Sequential sampling oscilloscopes normally display eye diagrams as a series of disconnected points on the screen. While these points accurately represent all the combinations of digitized bit patterns, each point is obtained from a separate trigger event, so there is no way to determine exact characteristics of any specific bit combination (Fig. 1a).



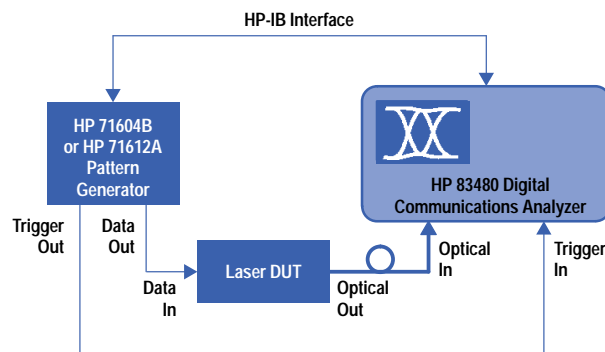
**Fig. 1.** Sequential sampling oscilloscopes show eye diagrams as a series of disconnected dots (a). Using the HP Eyeline display mode (b), the individual bit patterns can be distinguished.

When sampling live data there is no alternative, but when sampling repetitive waveforms such as pseudorandom binary sequence (PRBS) patterns it is often possible to show the individual bit sequences. This is done by synchronizing the oscilloscope trigger with the pattern repetition rate. In this case, the oscilloscope repeatedly triggers at the same point in the pattern, so the display is a sampled representation of that segment of the pattern.

This display mode, called pattern triggering, is commonly used in situations where the device under test can be stimulated with a digital pattern generator from a bit error rate tester (BERT). Pattern generators typically include a trigger output that can be set to produce a trigger pulse at the start of each pattern. The problem has been that until recently, it has not been possible to accurately display portions of the pattern far from the trigger point. While it is theoretically possible to show different parts of the pattern by increasing the oscilloscope delay, in reality this is impractical because of accuracy and jitter limitations in the oscilloscope time base.

The HP 83480 offers an optional *HP Eyeline display mode* (Fig. 1b), which overcomes this limitation. HP Eyeline display mode takes advantage of a new feature in the HP 71604B and HP 71612A pattern generators that allows the trigger point to be adjusted bit by bit within the pattern.

The HP Eyeline display mode runs as an application program that loads from the HP 83480's 3.5-in disk drive and allows the instrument to control the pattern generator over the HP-IB (IEEE 488, IEC 625). The equipment setup is shown in Fig. 2. (HP Eyeline display capability was first introduced in the HP 71501 Eye Diagram Analyzer using a different method to accomplish the same result.<sup>1</sup>)

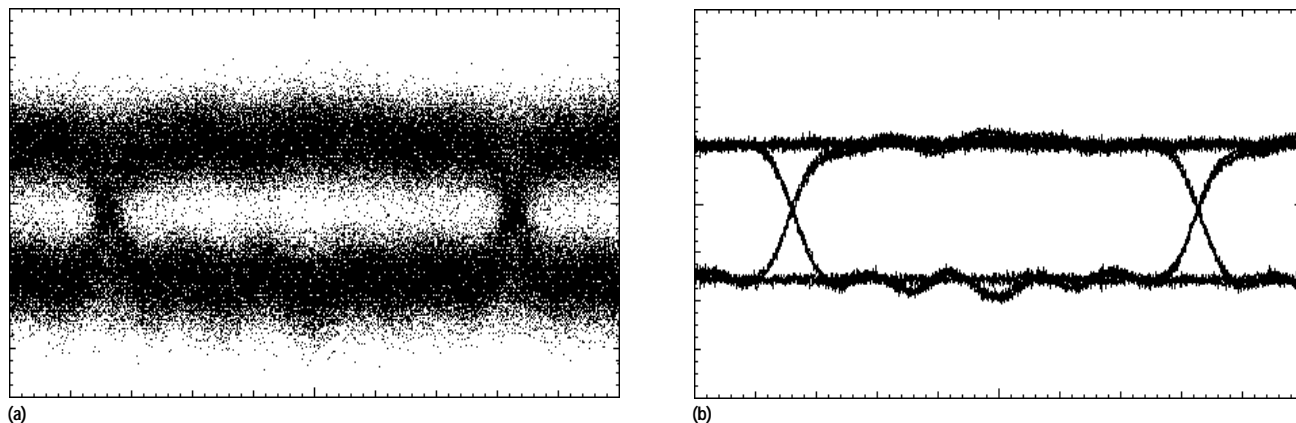


**Fig. 2.** Equipment setup for HP Eyeline display mode.

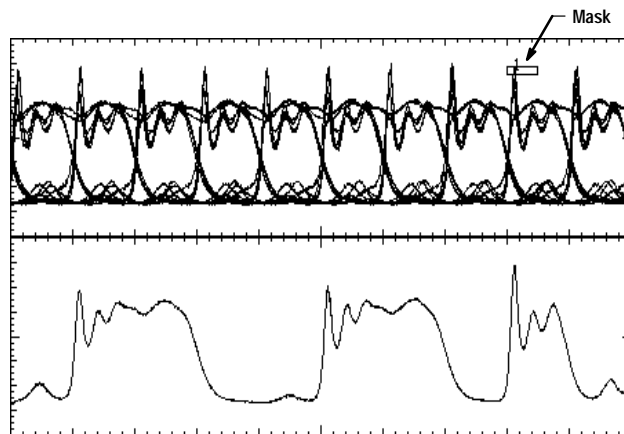
When the HP Eyeline program is running, the HP 83480 sets the pattern trigger location and samples one data point for each repetition of the pattern. The pattern generator transmits the entire data pattern between successive triggers. After an entire waveform record is taken (typically 500 to 4000 points, depending on the record length setting), the HP 83480 programs the pattern generator to delay the

trigger point by one bit and repeats the process. Eventually, the trigger point moves through the entire pattern, and the eye diagram shows all possible bit combinations.

One advantage of the HP Eyeline display mode is that it allows the use of signal averaging to reduce the effects of noise. (Averaging is not possible on an ordinary sampled eye because the result is the average between the two logic levels, causing the eye to collapse.) Signals too small to be seen without averaging can be readily identified using the HP Eyeline mode, as shown in Fig. 3. Another advantage is that it can aid troubleshooting by showing the bit sequence leading up to a mask test violation, as seen in Fig. 4. This can be used to identify the cause of pattern dependent errors.



**Fig. 3.** HP Eyeline mode allows the use of signal averaging to resolve signals from noise. The display in (a) shows how a low-level signal appears in the ordinary sampling oscilloscope display mode. The same signal is shown in (b) using Eyeline mode with 64-trace averaging applied.



**Fig. 4.** Error trace capture using HP Eyeline mode. The upper trace shows the complete eye diagram. The lower trace shows the bit pattern leading up to a mask violation. A custom mask was constructed to capture only those waveforms showing extreme overshoot.

Despite its advantages, the HP 83480's HP Eyeline display mode is not the solution to all problems. It can only be used with HP pattern generators having a programmable trigger output, so it is not suitable for analyzing live traffic. And because it relies on multiple repetitions of the pattern to generate the eye, it is most suitable for short pattern sequences that repeat rapidly. At an OC-48 data rate (2.48832 Gbit/s), for instance, a complete eye showing all bit combinations of a  $2^7 - 1$  PRBS pattern takes less than two seconds to generate. A complete  $2^{23} - 1$  PRBS pattern at the OC-3 data rate (155.52 Mbits/s), however, would take 7.3 years!

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## Reference

1. C. Miller, "High-Speed Digital Transmitter Characterization Using Eye Diagram Analysis," *Hewlett-Packard Journal*, Vol. 45, no. 4, August 1994, pp. 29-37.

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