

## Which Display Interpolation Should I Choose When Using the Yokogawa DL9000 or SB5000?

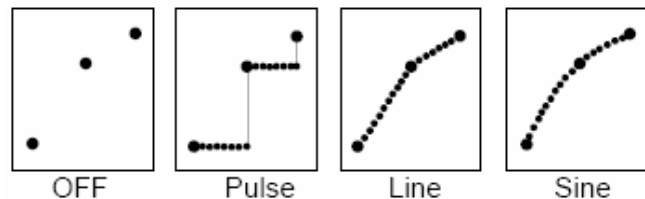
This article discusses the three types of display interpolation found in the Yokogawa DL9000 and SB5000 digital oscilloscopes. Each type is discussed and recommendations are given.

The Yokogawa DL9000 / SB5000 Digital Oscilloscope offers four choices of display interpolation. In order to avoid confusion with interpolation related to SAMPLING – the display interpolation is referred to as the *Dot Connect* feature. *Dot Connect* can be located on these oscilloscopes by pressing the FORM button.

It should be noted that enabling SAMPLING Interpolation actually creates many new sample points. The SAMPLING Interpolation feature can be located by pressing the SAMPLING/LENGTH button. *SAMPLING Interpolation* will be discussed in a future article.

*Dot Connect* is a well chosen name for the Display Interpolation feature because this is exactly what it does. On the display of the instrument, the dots (which represent waveform data samples) are connected together to create a visually pleasing display. The waveform is easier to see, more pixels are illuminated, and the oscilloscope is easier to use. As simple as this feature is – it remains important to understand the four choices. More importantly, it is prudent to know which of the four choices to make for your own waveform data.

The four choices of *Dot Connect* available to the operator are OFF, PULSE, LINE, and SINE. When a factory reset is applied, or when the instrument is initialized, the *Dot Connect* feature defaults to SINE (1).



**OFF** – No interpolation. Use this as a starting point or simply to view the raw display points. If the sample rate is high enough and Time/Div long enough, this method can be visually pleasing and sufficient.

**PULSE** – Interpolates between two display points by drawing a horizontal line to the time of the next display point, then connecting the end of that horizontal line to the next display point with a vertical line thus creating a step pattern.

**LINE** – Linearly interpolates between two points with a straight line.

**SINE** – Interpolates between two display points with using the  $\sin(x)/x$  function. Basically a small sine wave connects each pair of points. The amplitude of this sine wave is determined by the distance between those two points, among other things.

Enabling *Dot Connect* does not create new sample points. It does however create new display points. Enabling *Dot Connect* does not affect your sampled data in any way. The waveform's data record remains intact and unaffected. Cursor measurements and Parametric measurements are also each unaffected by the enabling *Dot Connect* feature.

The Dot Connect feature can, however, affect the way a waveform is viewed by the engineer, or end user. So, now that a basic understanding of each method has been established – it is fairly straight-forward to decide which to use; and, several examples will be presented.

**Select OFF** to reveal any potential inconsistencies which may have appeared while previously using an inappropriate *Dot Connect* mode. OFF is always a good starting point; If you like what you see, you can always simply leave it off. Increasing the sample rate in this mode may increase not only the sample record length, but also the display record length. After getting comfortable with *Dot Connect*, choose one of the remaining methods.

**Select PULSE** to reveal accurately the vertical amplitude of each display sample point. In an All Points Display, such as the Yokogawa display, you may rest assured that every sample in the record is represented in some way (illuminated pixel and/or illumination level of each pixel) on the display. Selecting PULSE can make this very apparent, however, slow rise time edges can hide behind this method. Likewise, with square waves, an insufficient sample rate can lurk un-noticed.

**Select LINE** to connect each display point with a straight line; this mode is most appropriate for reconstructing straight-edged signals such as digital waveforms or square waves.

**Select SINE** to connect each display point with a smoothed line using the  $\text{sine}(x)/x$  window and algorithm. SINE interpolation assumes that all of the frequency content in the sampled waveform lies below one-half of the sample rate that the waveform was sampled at; and so you should be sure that this is the case as well – Otherwise, there will be a violation of Nyquist's criterion.

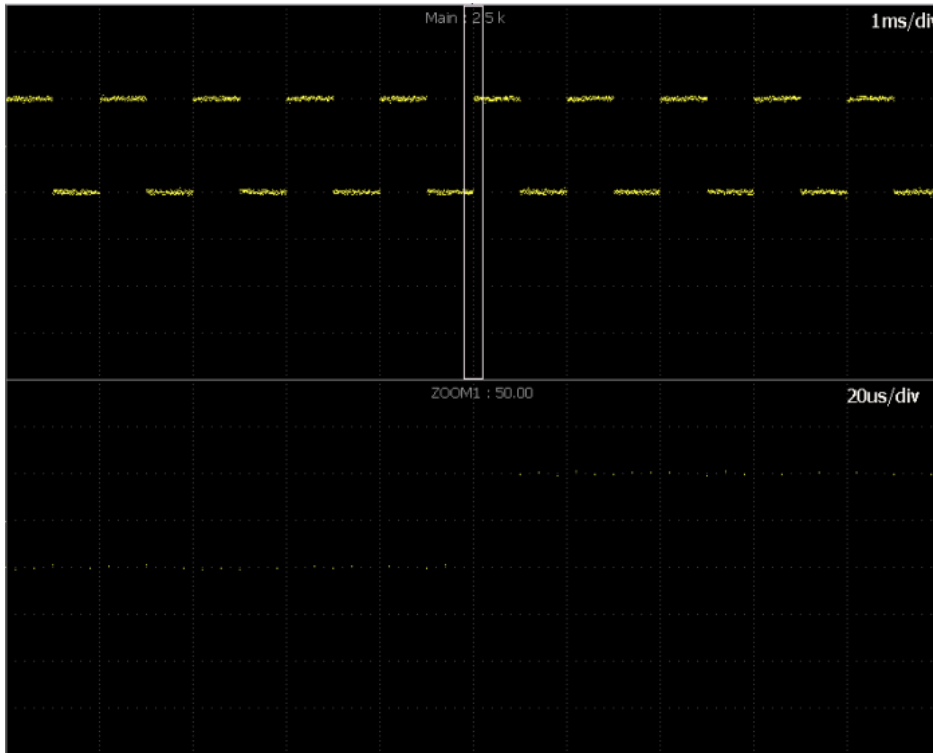
SINE is appropriate for reconstructing any smooth waveforms or irregular waveforms which you desire to be smoothed by the  $\text{sine}(x)/x$  algorithm. Using SINE to smooth an square wave which violates the assumption mentioned above, on the other hand, can result in overshoot and undershoot anomalies which are not

reality. Increasing the sample rate to meet the Nyquist's Criterion is the obvious way to avoid these effects. If that is not possible, choose OFF or LINE.

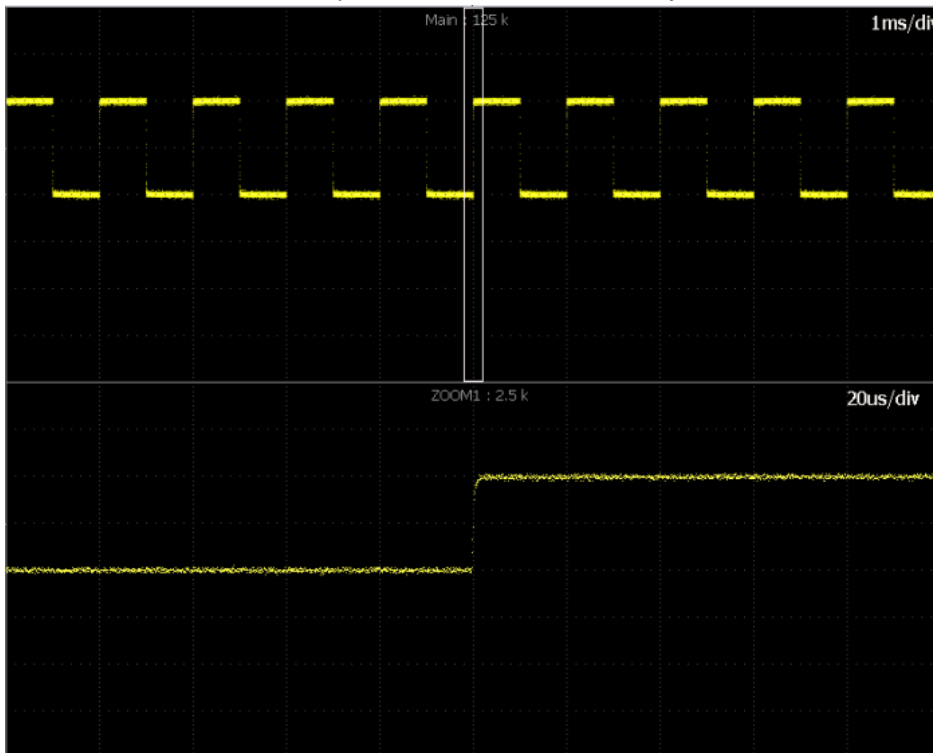
It should be noted that if the outcome for a given *Dot Connect* selection is discovered to be inappropriate or unsatisfying, simply make a new selection; *reacquiring the waveform is unnecessary*. Therefore, it is convenient to experiment with your waveform acquisition.

On the following pages, several examples of display interpolation, or *Dot Connect*, can be examined in order to gain further understanding of each of the methods.

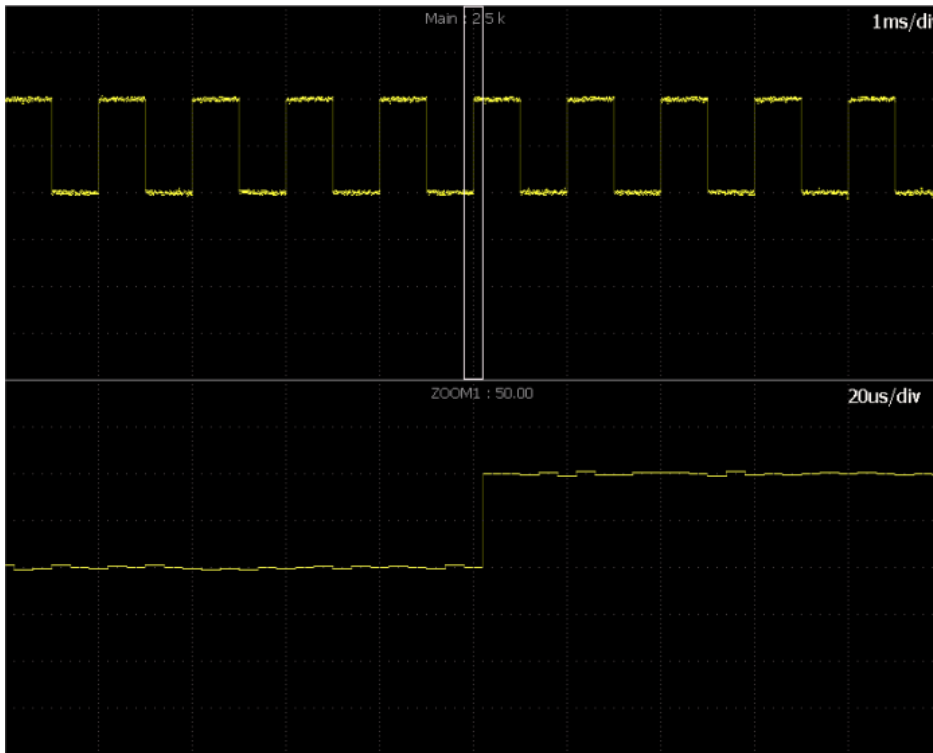
DOT CONNECT=OFF; Sample Rate=LOW – Satisfactory, but insufficient for study of leading edge rise time



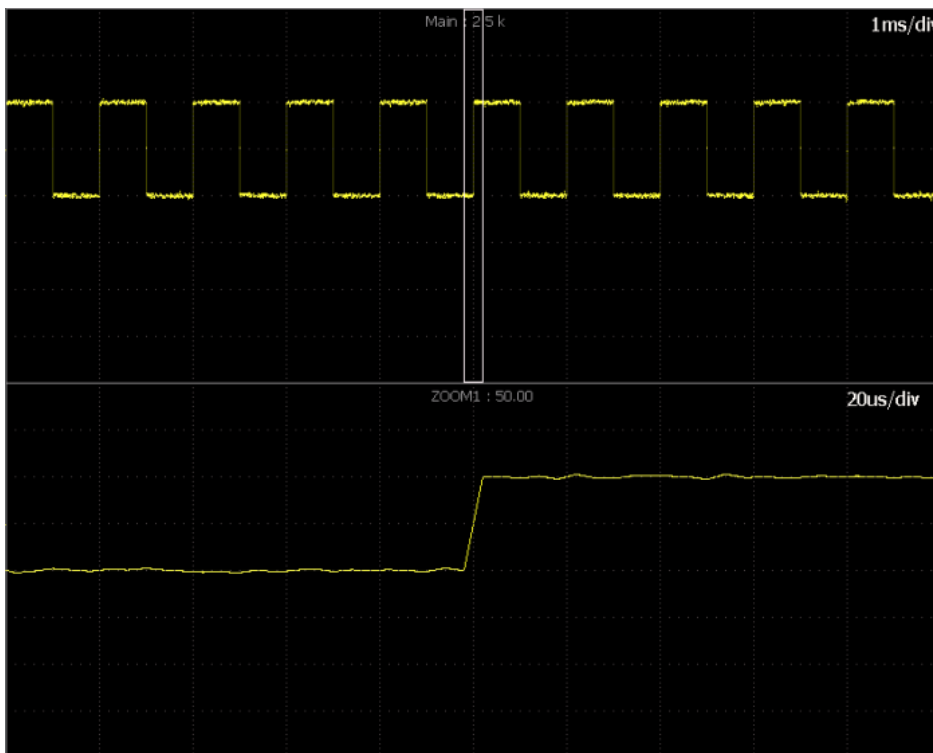
DOT CONNECT=OFF; Sample Rate=HIGH - Satisfactory



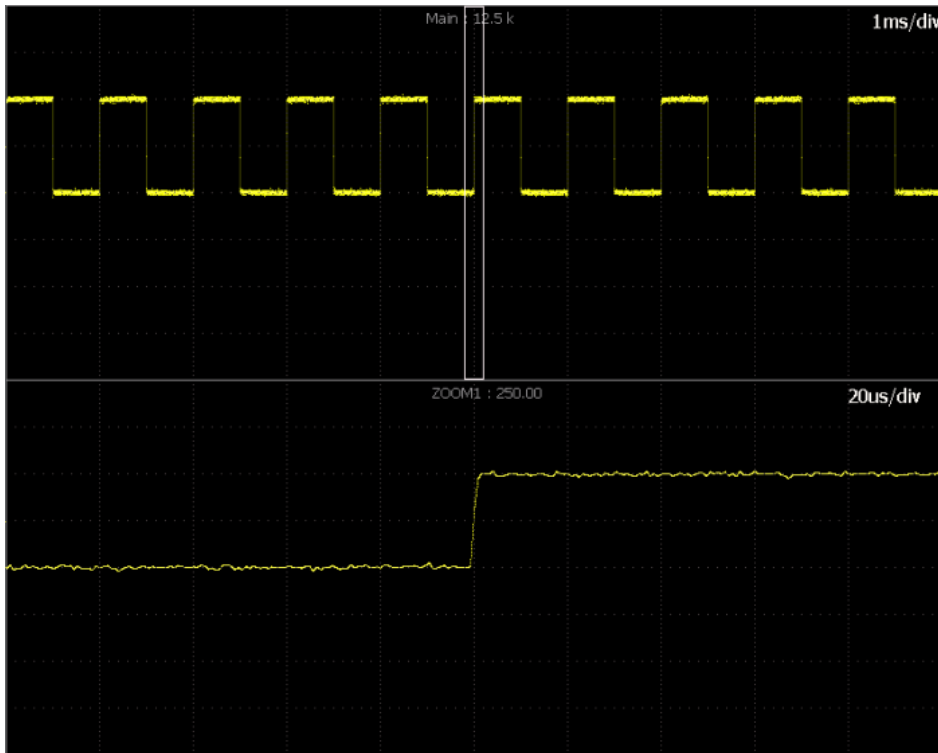
DOT CONNECT=PULSE – If observation of the rising edge is desired, choose a different interpolation method



DOT CONNECT=LINE; SAMPLE RATE=LOW – Choose a higher sample rate

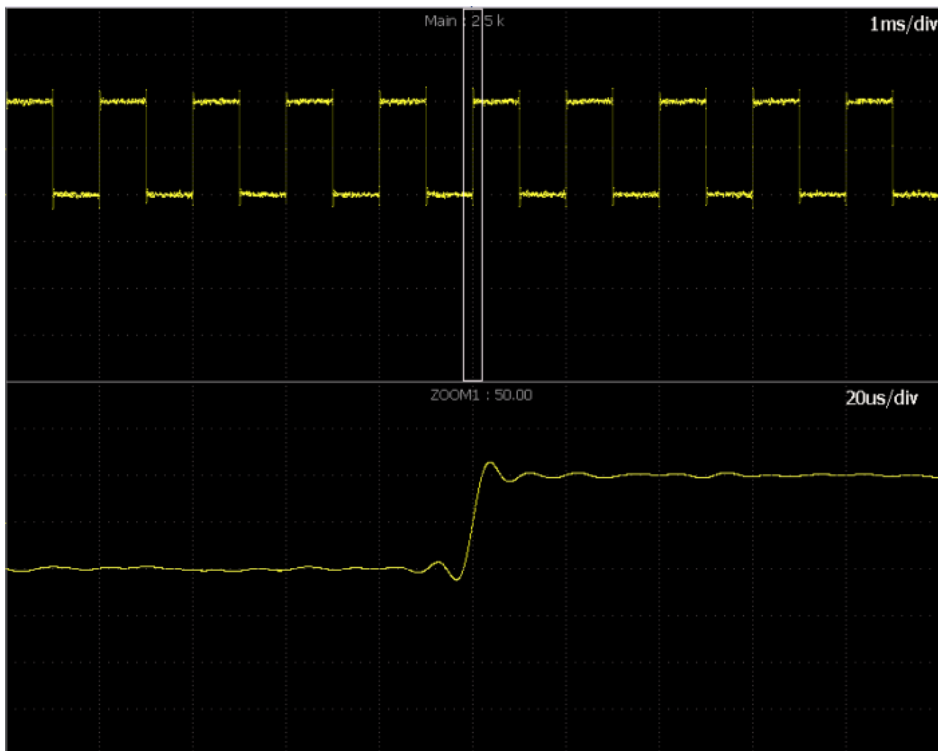


DOT CONNECT=LINE; SAMPLE RATE=HIGH - Satisfactory



DOT CONNECT=SINE;

Nyquist Criterion Violated (Either choose higher sample rate or use other display interpolation method)



Choosing a display interpolation method does not have to be complicated. Take the time to experiment with the principles detailed in this article and you will find that selecting the correct method becomes second nature. Again, if the outcome for a given *Dot Connect* selection is discovered to be inappropriate or unsatisfying, simply make a new selection and remember that reacquiring the waveform is unnecessary.

(1) DL9000 Series Digital Oscilloscope USER'S MANUAL, IM701310-01E 7<sup>th</sup> Edition, Yokogawa Electric Corporation, 2008, Page 8-8

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