Digital Storage Oscilloscope

1. **Horizontal :**
   It is used to set the time base scale (time/div) and zoom into the waveforms
2. **Vertical :**
   It is used to set the level scale (volts/div)
3. **Trigger :**
   It is used to control the trigger level and mode
4. **Acquire :**
   It determines how many samples are used to reconstruct a waveform
5. **Input Channel :**
   Its input impedance has 1MΩ , 50Ω and 75Ω . The default impedance setting is 1MΩ high impedance
6. **Autoset :**
   The oscilloscope will automatically identify the type of waveform and adjusts the settings in order to steadily display the test waveform.

A An Introduction to Digital Storage Oscilloscope

1. Basic Type of Oscilloscope

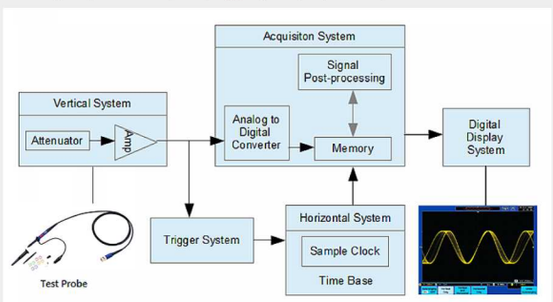
Analog Oscilloscope :

It uses the analog circuit design for signal process and waveform display. It is real time signal display at cathode ray tube but it cannot support the waveform storage.

Digital Storage Oscilloscope :

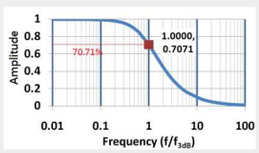
It uses the digital circuit design for signal process and waveform display. It can support the signal post-processing and store the waveform easily.

Digital Storage Oscilloscope has main parts as below :
Vertical System, Horizontal System, Trigger System, Acquisition System



2. Vertical System : Bandwidth & Rise Time

Bandwidth is the most important characteristic of the oscilloscope. It defines the maximum supported frequency before the applied sine wave signal reduced to -3dB attenuation. Normally, User needs a probe to measure the signal. The probe has a limited bandwidth. If the user combines the oscilloscope and the probe, it will make a system bandwidth. Without affecting the oscilloscope bandwidth, the recommended probe bandwidth should exceed 1.5 times than oscilloscope bandwidth.

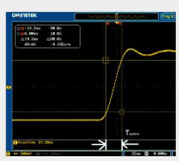


3. Rise Time Calculation

$T_{rise\_10\text{-}90} = 0.35/BW_{scope} = 0.35/f_{scope}$

This 0.35 factor is based on a simple one pole model Gaussian response.

Ex : Measure rise time T measure is 19.2ns which shows at below figure.
500MHz oscilloscope GDS-3504 own rise time T scope is 0.7ns.
350MHz test probe GTP-351R own rise time T probe is 1.0ns



The True Signal Rise Time T_{signal} will Become :

$$T_{signal} = \sqrt{T^2_{measure} - T^2_{scope} - T^2_{probe}}$$

$$T_{signal} = \sqrt{(19.2)^2 - (0.7)^2 - (1.0)^2}$$

$$T_{signal} = 19.16ns$$

Rule of Thumb : BW_{scope} = 3 to 5 ✲ f_{max} of Test Signal

4. Trigger System

The trigger makes the waveform appear steadily on the oscilloscope display. When the test signal meets the trigger setting, the oscilloscope starts to capture the signal.

The edge trigger is the simplest type of trigger system. An edge trigger mode triggers when the signal crosses an amplitude threshold with either a positive or negative slope.

The trigger condition includes trigger level, slope, source of the trigger signal, coupling, filtering, trigger type and trigger type and the others.

5. Acquisition & Horizontal System : Sample Rate & Memory Depth

Under the acquisition process, the A/D converter samples the analog input signals and converts them into digital format for internal processing. The digital format waveform is stored in the waveform memory.

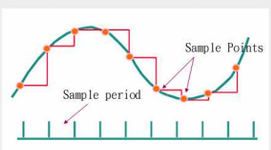
The sample rate or sample frequency f_s define the number of waveform samples per unit of time taken from a continuous signal to make a discrete signal.

The Nyquist theorem states that the perfect reconstruction of a signal is possible when the sampling frequency must be at least twice as fast as the highest frequency of the signal.

$f_s \geqq 2\ f_{max}$ of Test Signal

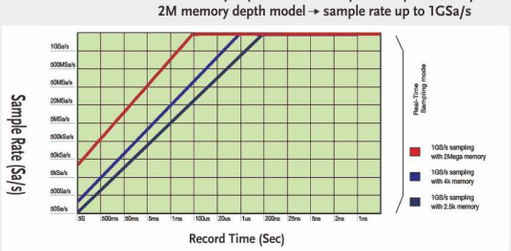
But the Nyquist theorem can be assumed under ideal condition, so the Nyquist sample rate is not enough.If the sample rate is not fast enough, components with high frequency will cause aliasing and make false waveform displayed. The sample rate must be 3 or more times faster than the highest frequency of the signal.

The number of samples in an oscilloscope can store is defined as memory depth.
Only if the memory is large enough could the waveform be recorded over a long period of time.



6. Calculation of Memory Depth

Memory Depth (Sample points) = Sample rate (Sa/s) ✲ Record Time (sec)
In 1ms record time condition, 4k memory depth model → sample rate up to 4MSa/s
25k memory depth model → sample rate up to 25MSa/s
2M memory depth model → sample rate up to 1GSa/s



Ex: Above figure has 3 types of memory depth (2M/25k/4k) oscilloscope model with 1GSa/s sampling rate.

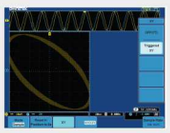
C Digital Storage Oscilloscope Application

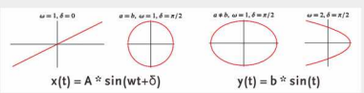
1. FFT Measurement

To observe the fundamental and harmonic frequency components of a signal, the FFT function can transfer the test signal from time domain to frequency domain.

2 . Lissajous Figures

Two phase-shifted sine wave input to the oscilloscope in X-Y mode and the phase relationship between the signals is presented as a Lissajous figure.





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