Basic Electronics Series

Introduction to Oscilloscopes

Oscilloscope Basics

- What is an Oscilloscope?
  - Visual voltmeter
  - Displays a representation of voltage over time
- Two basic types…
  - Analog
    - Typically uses cathode ray tube (CRT) for display and analog processing circuits
  - Digital
    - Typically uses LCD for display and digital processing circuits

Analog Oscilloscope

- Earlier technology
- Larger and heavier
- Uses higher voltages and currents for operation
- Uses analog circuitry to control electron beam sweep

Digital Oscilloscope

- Newer technology
- Smaller and lighter, more compact
- Operates at lower voltages and draws less current while operating
- Uses digital circuits to process inputs and display results

Common Features

- Voltage is on vertical (X) axis
  - Normally adjustable for volts be division
- Time is on horizontal (Y) axis
  - Normally adjustable for seconds per division
- Display uses graticule with time and voltage grid
- Most multi-trace CRT oscilloscopes use a single electron gun and shared time

Time Scale

- Depending upon oscilloscope design, the time scale may run from a lower limit of 1.0 nanosecond per division to an upper limit of 100 seconds per division.
- In most oscilloscopes, the time scale can be offset or delayed by as much as several hundred seconds
  - Introducing delay has the effect of moving the active trace horizontally on the screen

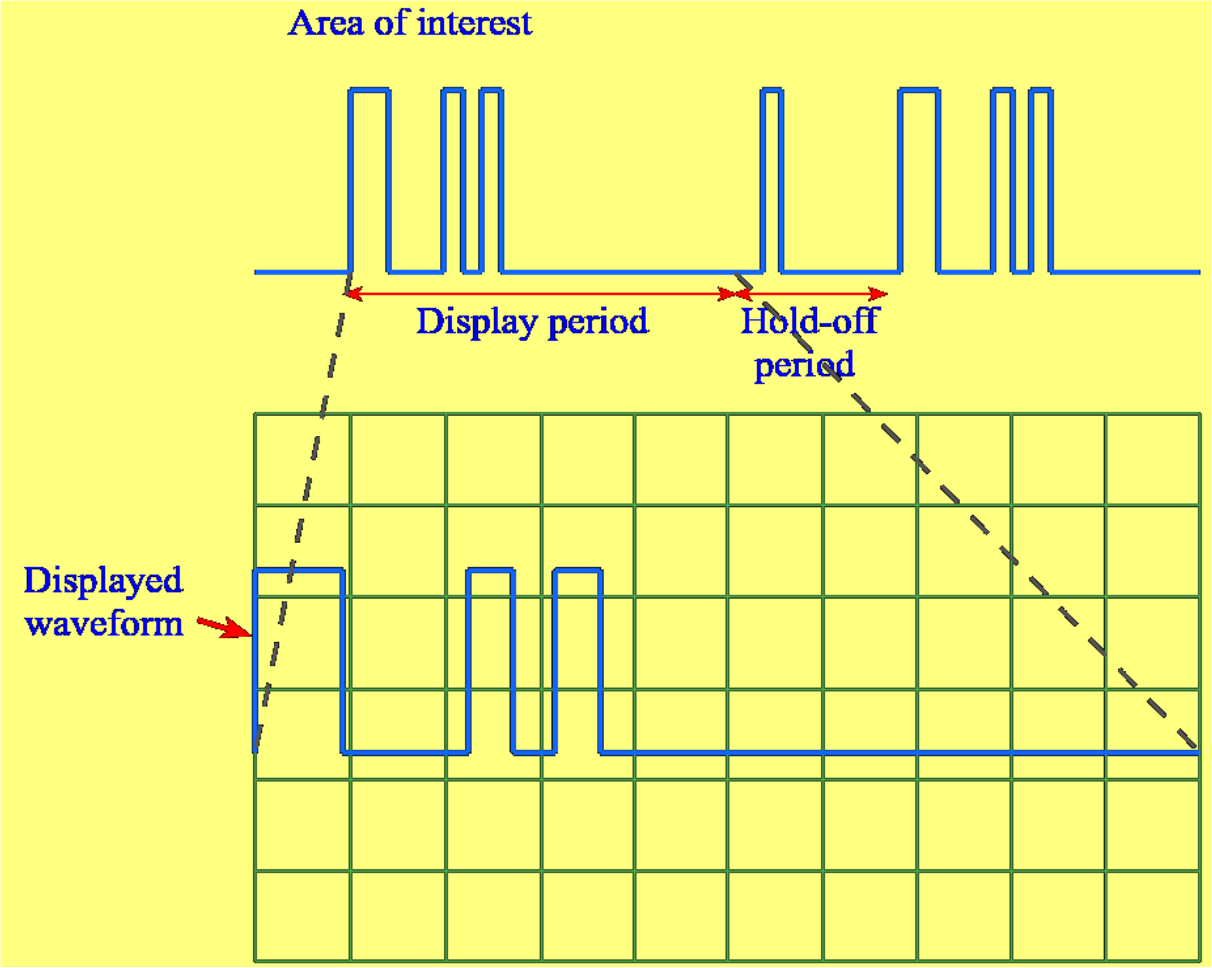
Voltage Scale

- Typical voltage scale adjustments run from 500 microvolts per division to 10 volts per division.
- Most oscilloscopes allow the trace(s) to be vertically offset by amounts equivalent to tens of volts, depending upon the base volts per division setting.
  - Introducing a vertical shift is equivalent to adding a DC offset to the measured voltage.

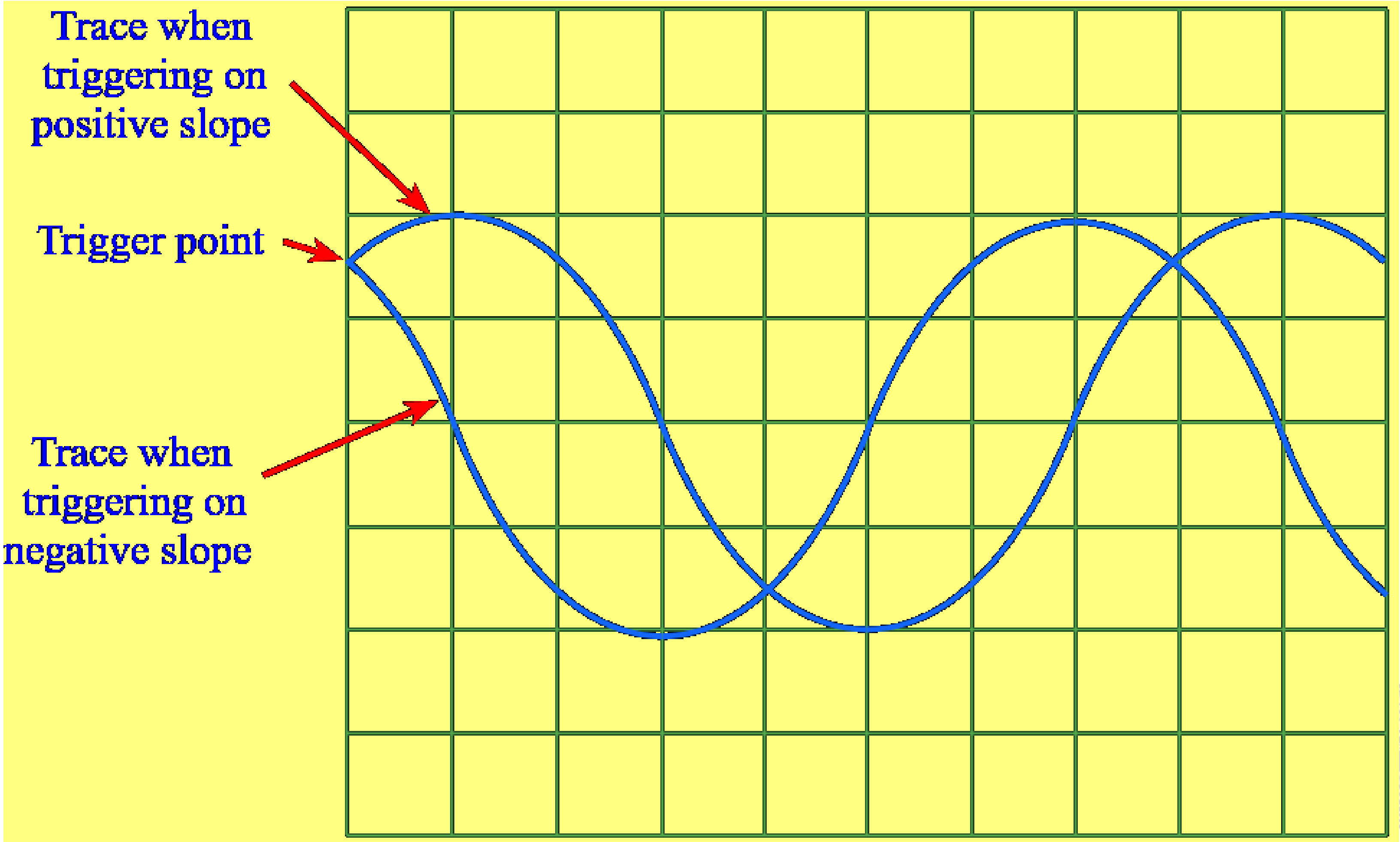
Triggering

- Triggering is the process of capturing a waveform based on various criteria you specify. The trigger makes repetitive waveforms appear static on the oscilloscope display by capturing at the same point in the signal and repeatedly overwriting the signal with itself.

Triggering


Area of interest
Display period
Hold-off
period
Displayed
waveform

Triggering



Trace when triggering on positive slope
Trigger point
Trace when triggering on negative slope

Probe Compensation

All oscilloscopes have a certain amount of inherent capacitance in parallel with their input resistance. Typically, this capacitance is in the low 10's of picofarads. When measuring DC, this is not a problem. When measuring AC or mixed signals, however, it becomes critical, because as the frequency increases, the input capacitance starts acting as a low pass filter.

Probe Compensation

Probe compensation is the process whereby the probe capacitance is adjusted to compensate for the effects of the inherent input capacitance of the oscilloscope. Properly compensating the probe is necessary to ensure the best possible accuracy or linearity in measurement results.

Probes are normally in need of compensation *only* when in the 10X attenuated mode.

Probe Compensation

- A poorly compensated probe causes two main types of measurement inaccuracies.
  - The first is incorrect amplitudes.
    - Comparing a measurement made with a properly compensated probe to measurements with an undercompensated or an overcompensated probe shows significant amplitude variation even at low frequencies.

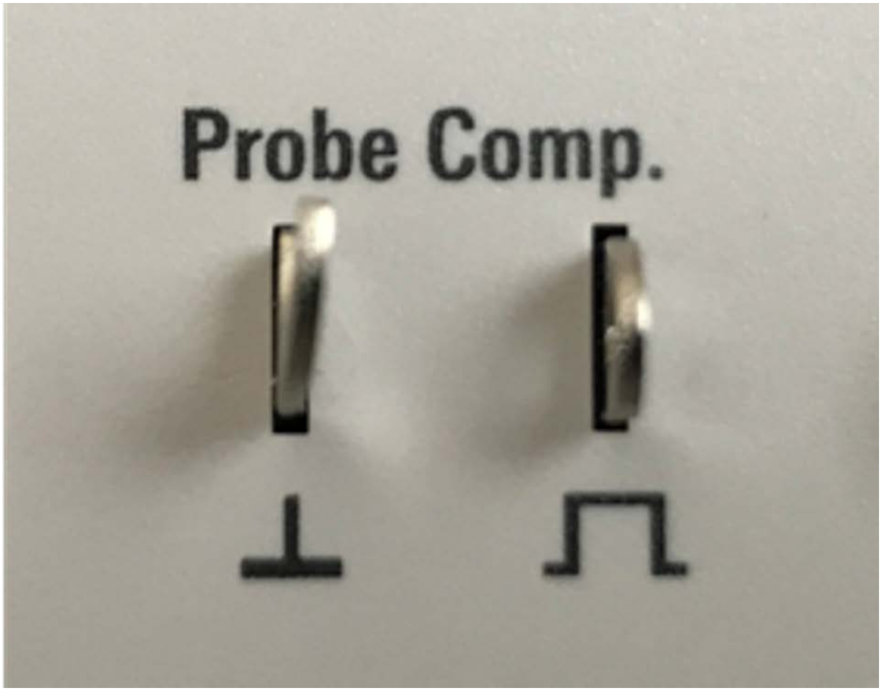
Probe Compensation

- The second consequence of incorrect probe compensation is distorted waveforms, more specifically, changes in the rise and fall times of pulsed signals.
  - ***It is important to remember that these inaccuracies increase with increasing frequency.***

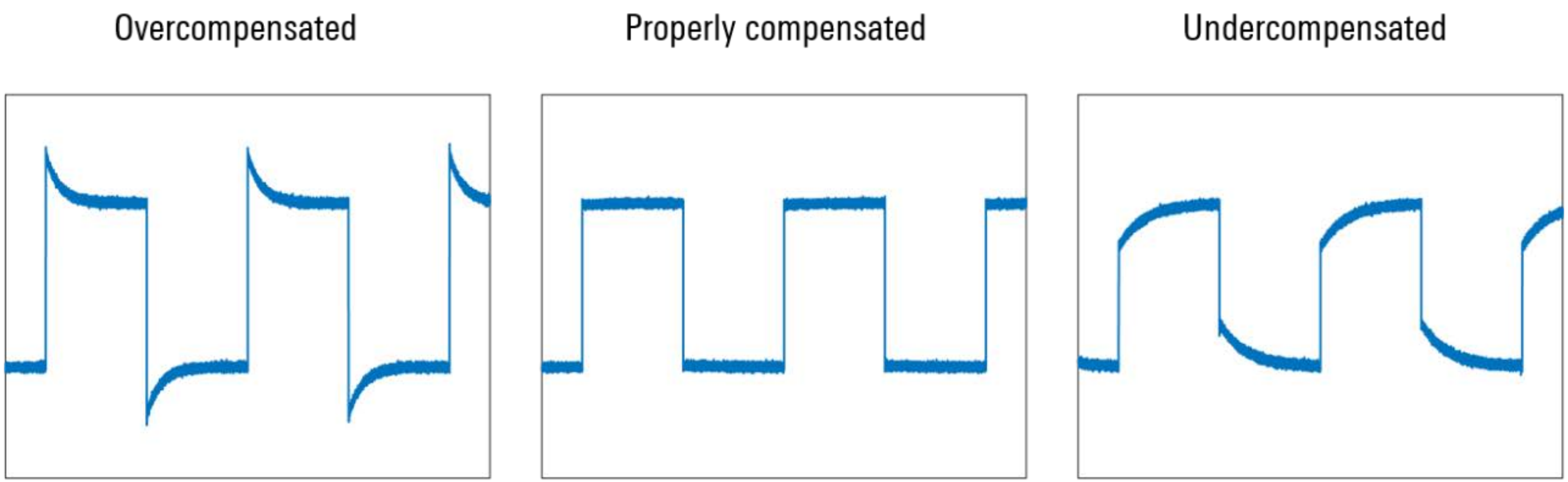
Probe Compensation

Probes should be compensated before first use or before making any important measurements. Since different oscilloscopes have different input capacitances, a probe needs to be compensated whenever it is moved to a different oscilloscope. Moving between ports on the same oscilloscope is usually okay, yet compensating a probe becomes more important the higher the signal frequency is.

- Most oscilloscopes have a 1kHz square wave generator output used for this purpose.
- Best practice is to use a non-conductive tool for compensation adjustments.

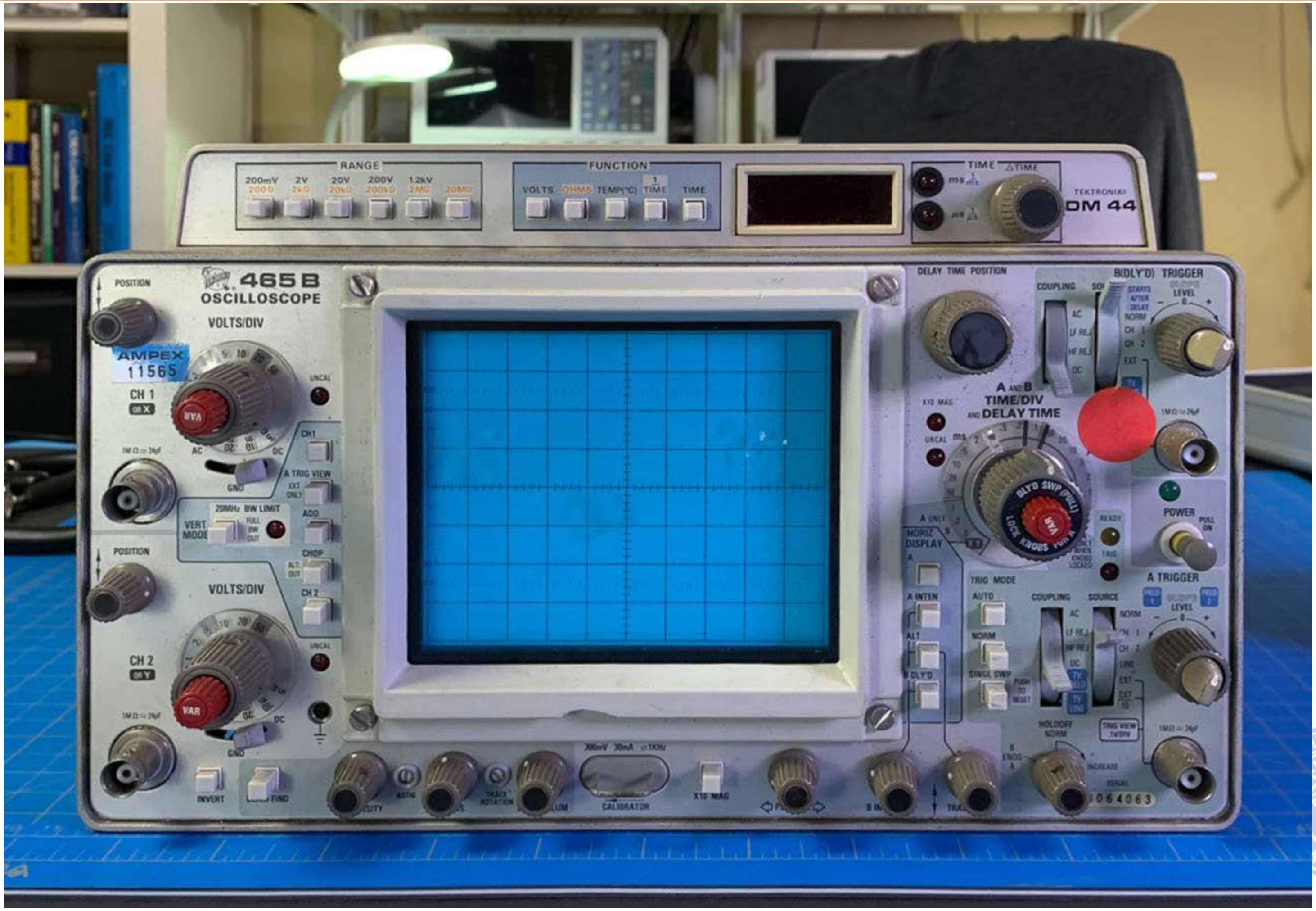


Probe Compensation



Compensation adjustments are made by adjusting the trimmer capacitor on the probe body or connector body until the proper waveform is achieved. This is done with the probe connected across the 1kHz square wave output from the oscilloscope waveform generator.

Tektronix 465B



- Dual trace oscilloscopes will usually have two sets of vertical controls
- The large knob sets the volts per division value
- The small knob sets the vertical position or offset
- Each trace has its own input jack, BNC's on the 465B
- Note the input selectors beneath the large knobs

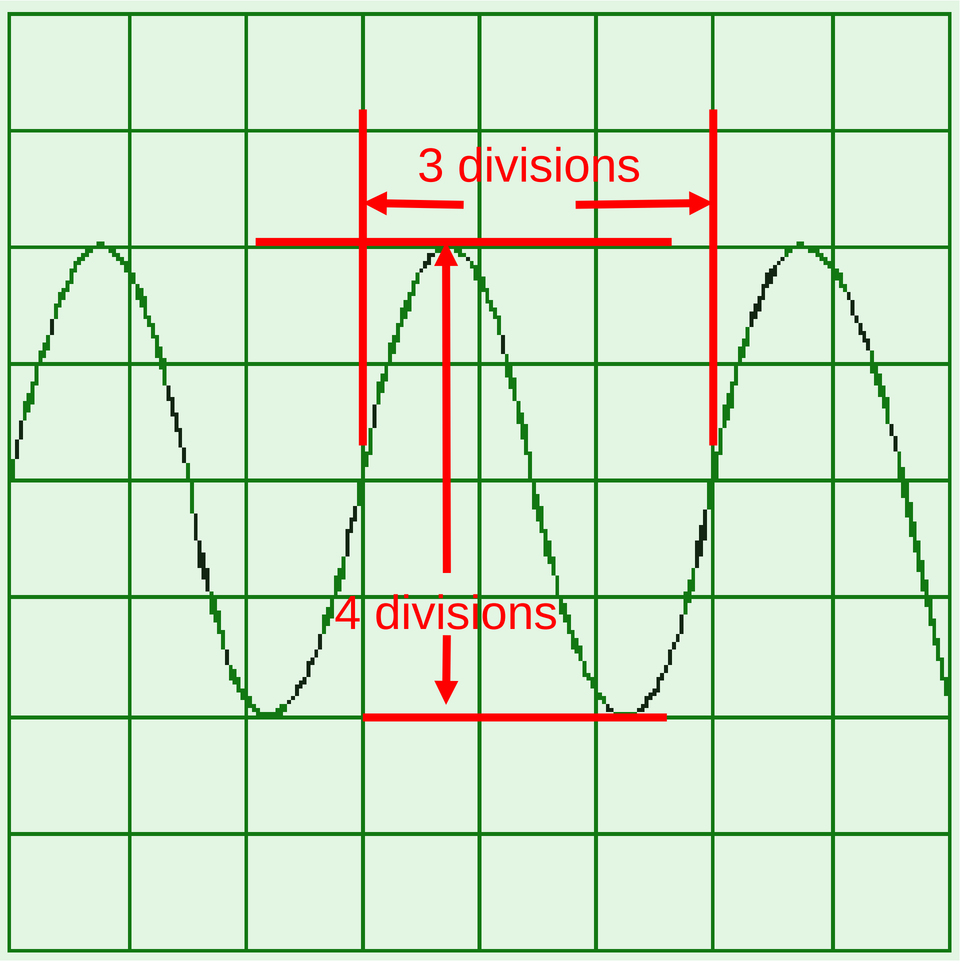
Input Settings

- The vertical or voltage input can usually be selected to either AC, DC, or GND
  - DC setting will input a composite AC and DC signal
  - AC setting will block any DC input and only allow the AC component to get in
    - This is useful when looking for AC ripple on a large DC value

Input Selector

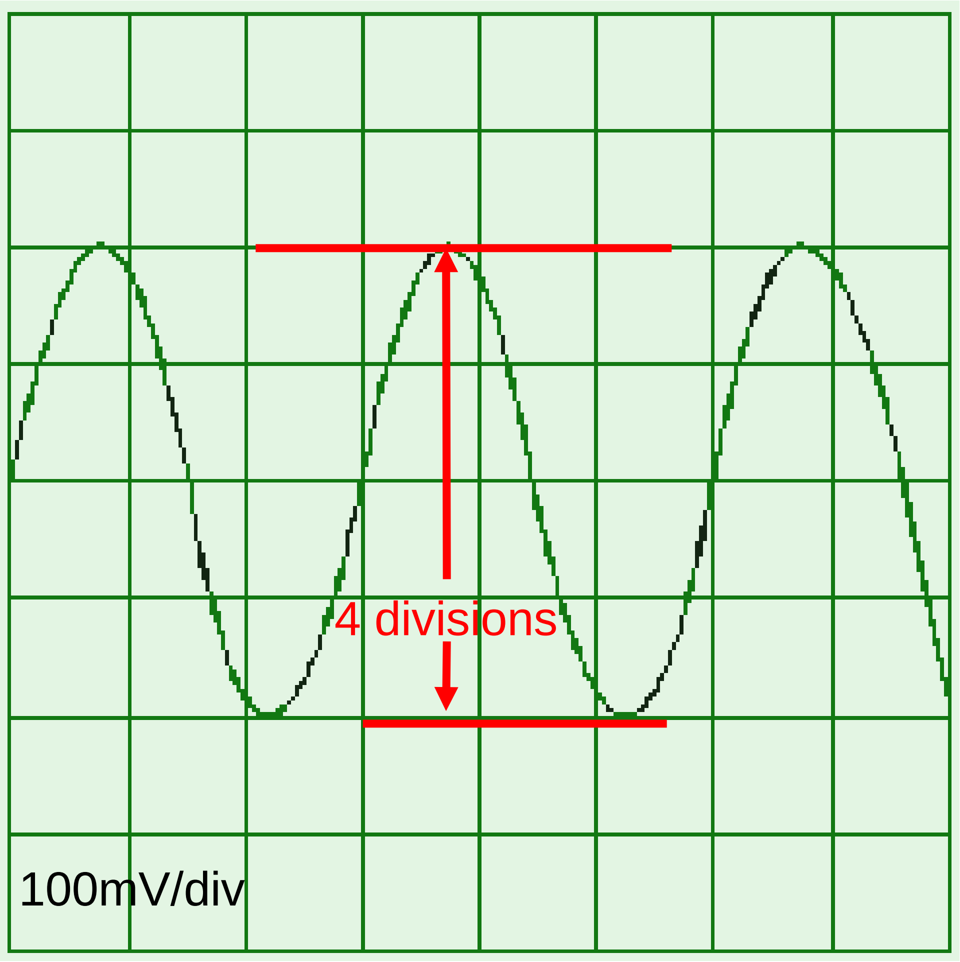
- The input selector switch controls the flow from the input jack to the vertical amplifier(s)
- In the GND position, the input of the vertical amplifier is grounded to provide a ground reference and to allow the input coupling capacitor to precharge

Reading the Oscilloscope



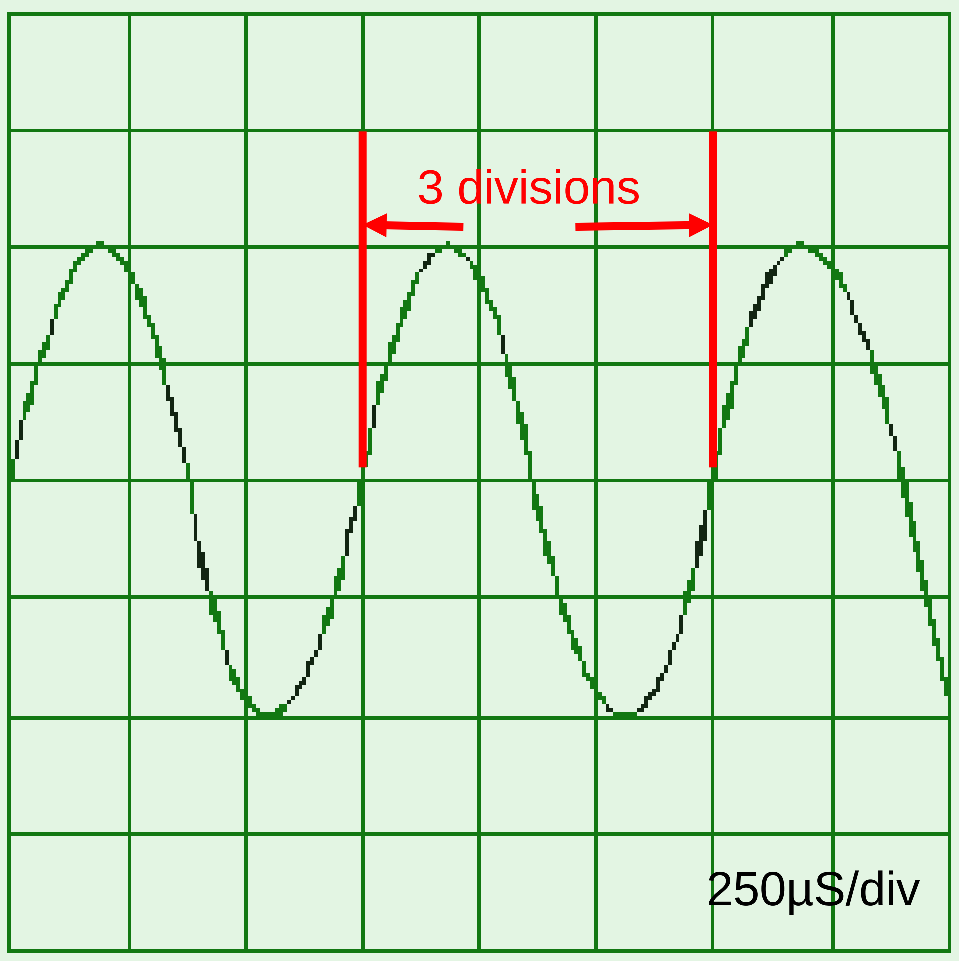
- This trace has a waveform that occupies three divisions horizontally and four divisions vertically.

Reading the Oscilloscope



- If the vertical scale setting is adjusted to 100mV per division, this waveform would have a peak-to-peak voltage of 400 millivolts.

Reading the Oscilloscope

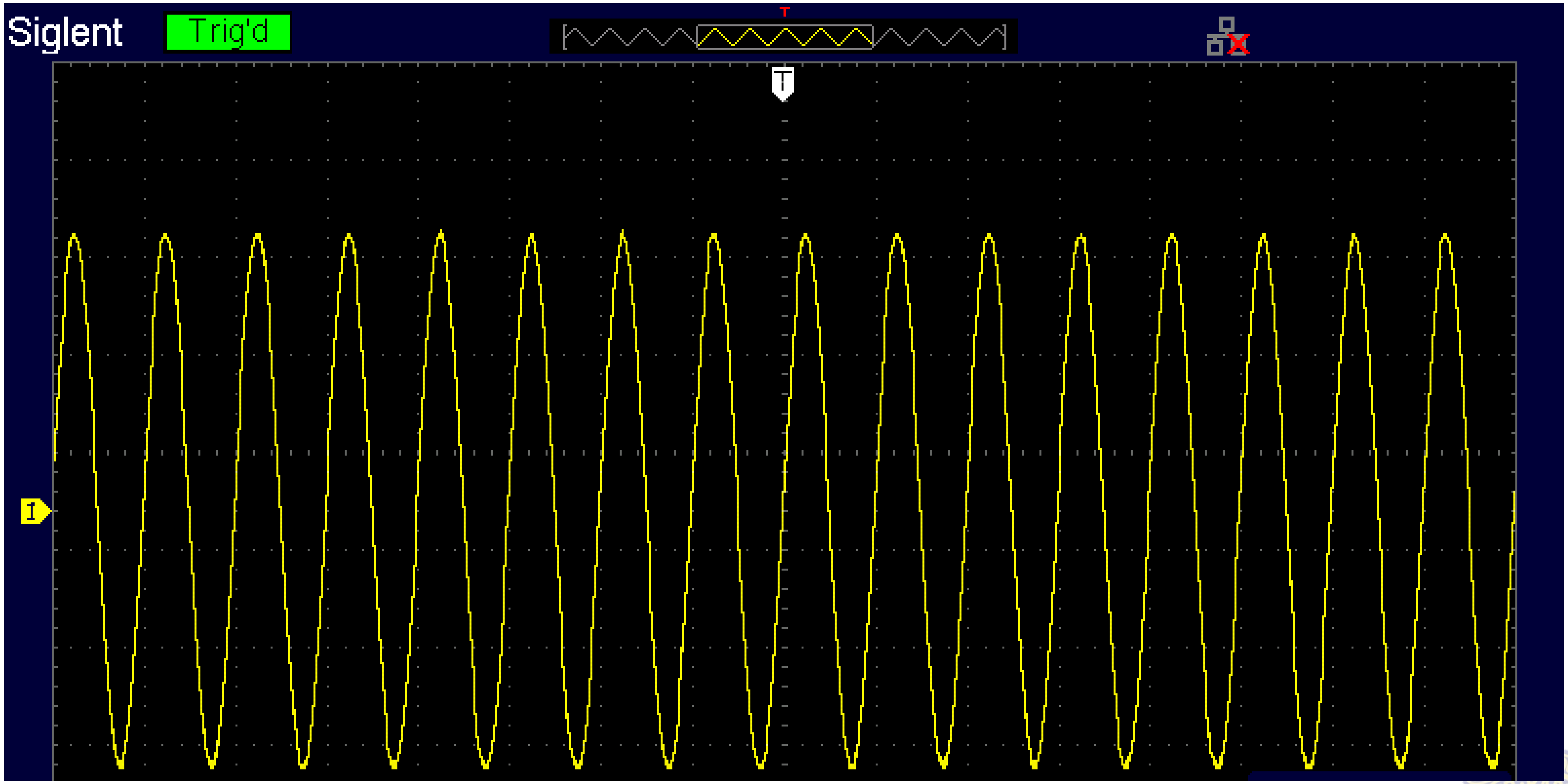


- If the horizontal scale setting is adjusted to 250µS per division, this waveform would have period of 750µS, which is equivalent to a frequency of 1333.333Hz

Reading the Oscilloscope

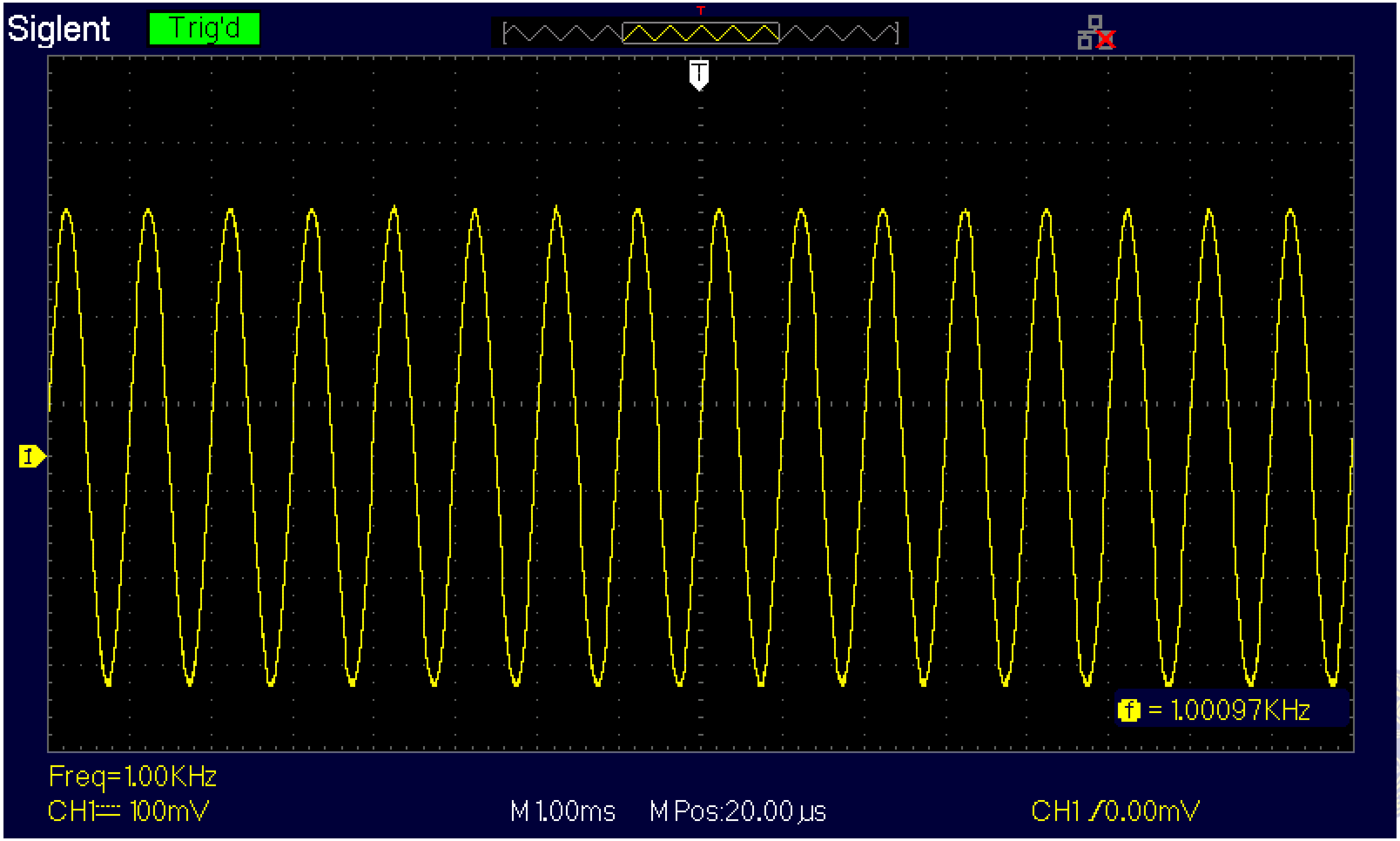
- To convert from period to frequency, divide the period into 1…
  - Frequency = 1 / Period
  - Period = 1 / Frequency
- Oscilloscope provides the period of a waveform cycle – count the divisions that the waveform cycle occupies and multiply by the timebase value.
  - Example – a single cycle of a waveform occupies three divisions and the timebase is 1mS/div – period = 3mS; frequency = 1/.003 = 333.333Hz

Reading the Oscilloscope

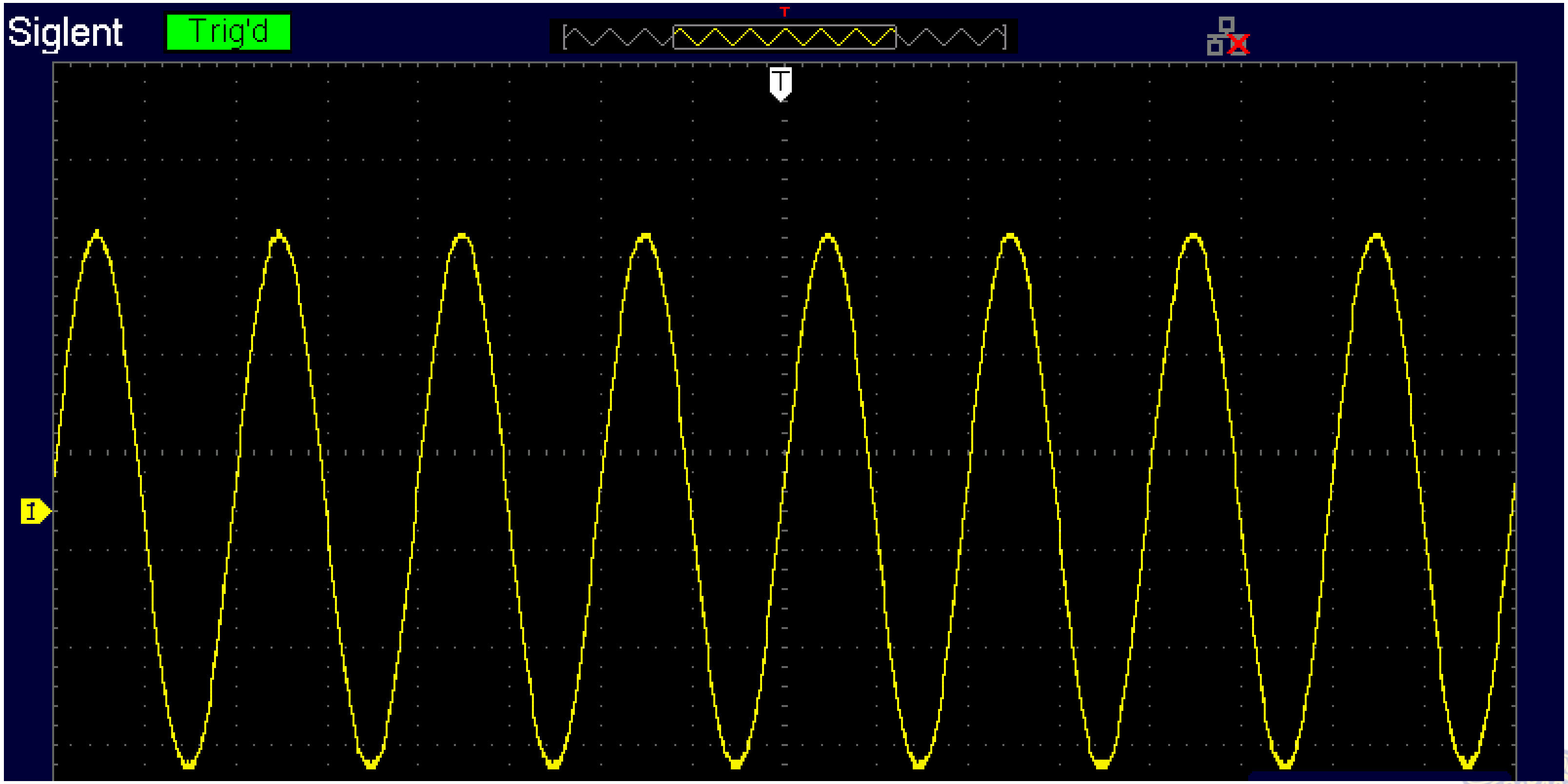


Time base is set to 1mS per division. What is the frequency?

Reading the Oscilloscope

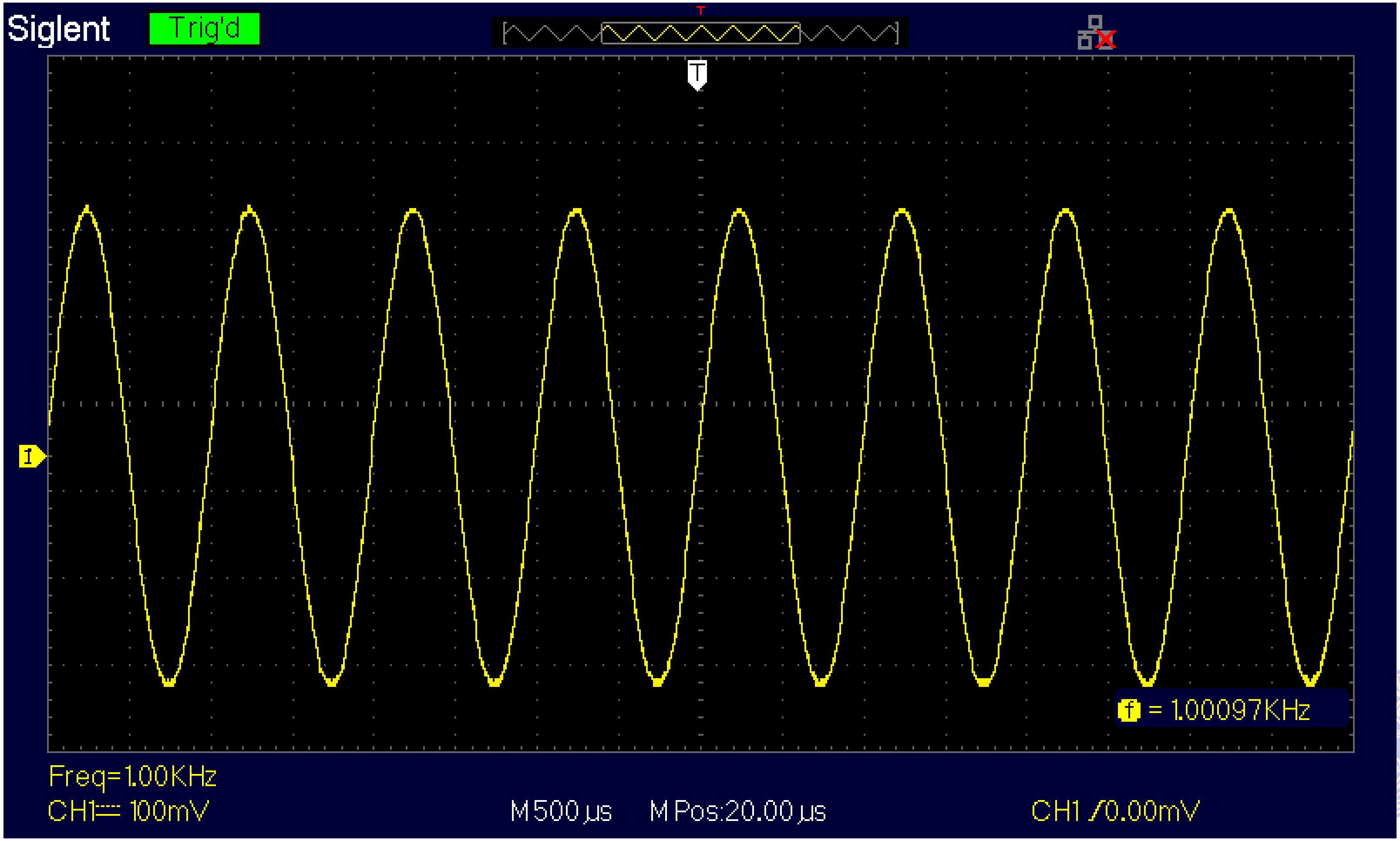


Reading the Oscilloscope

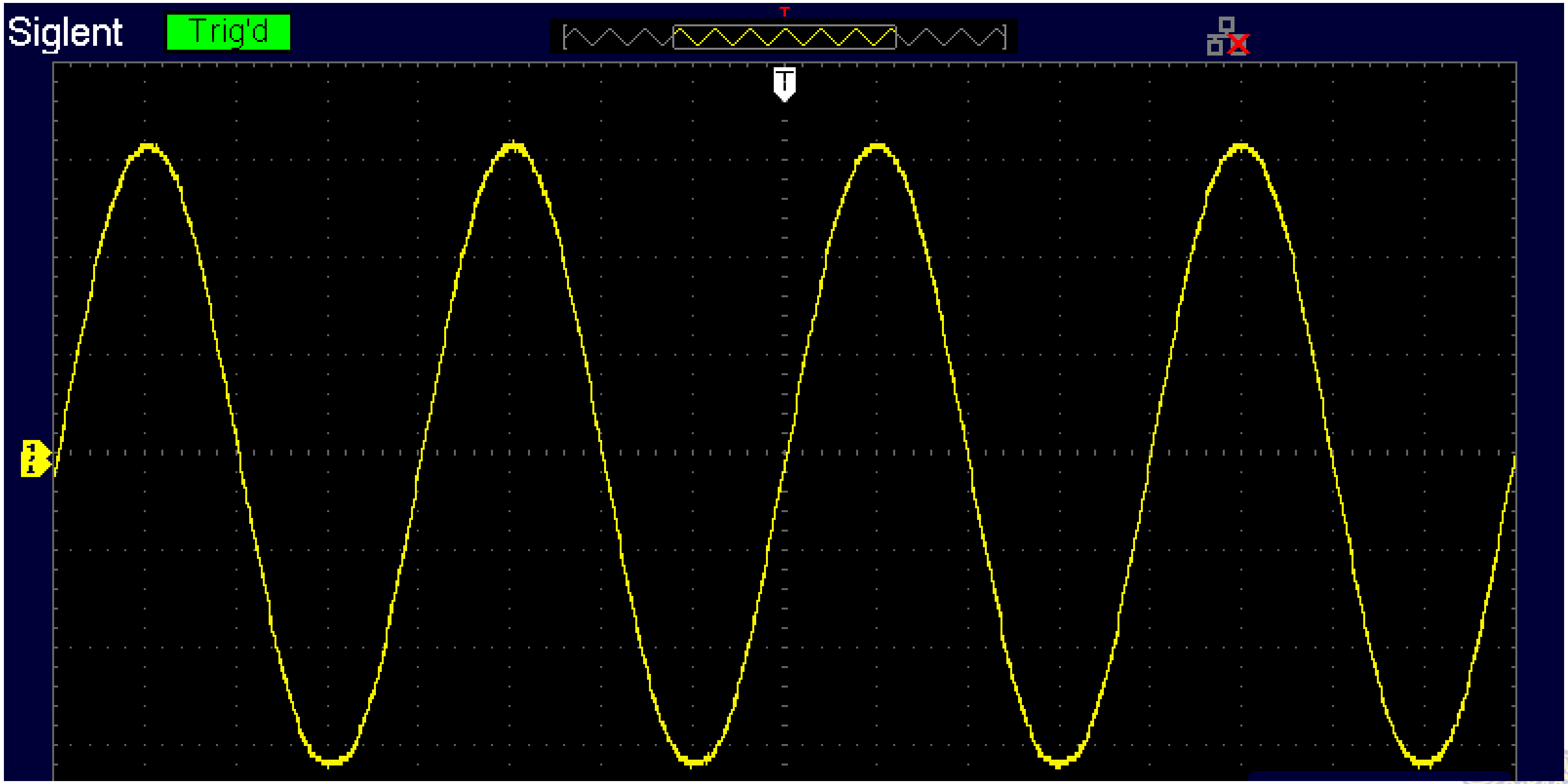


Time base is set to 500µS per division. What is the frequency?

Reading the Oscilloscope

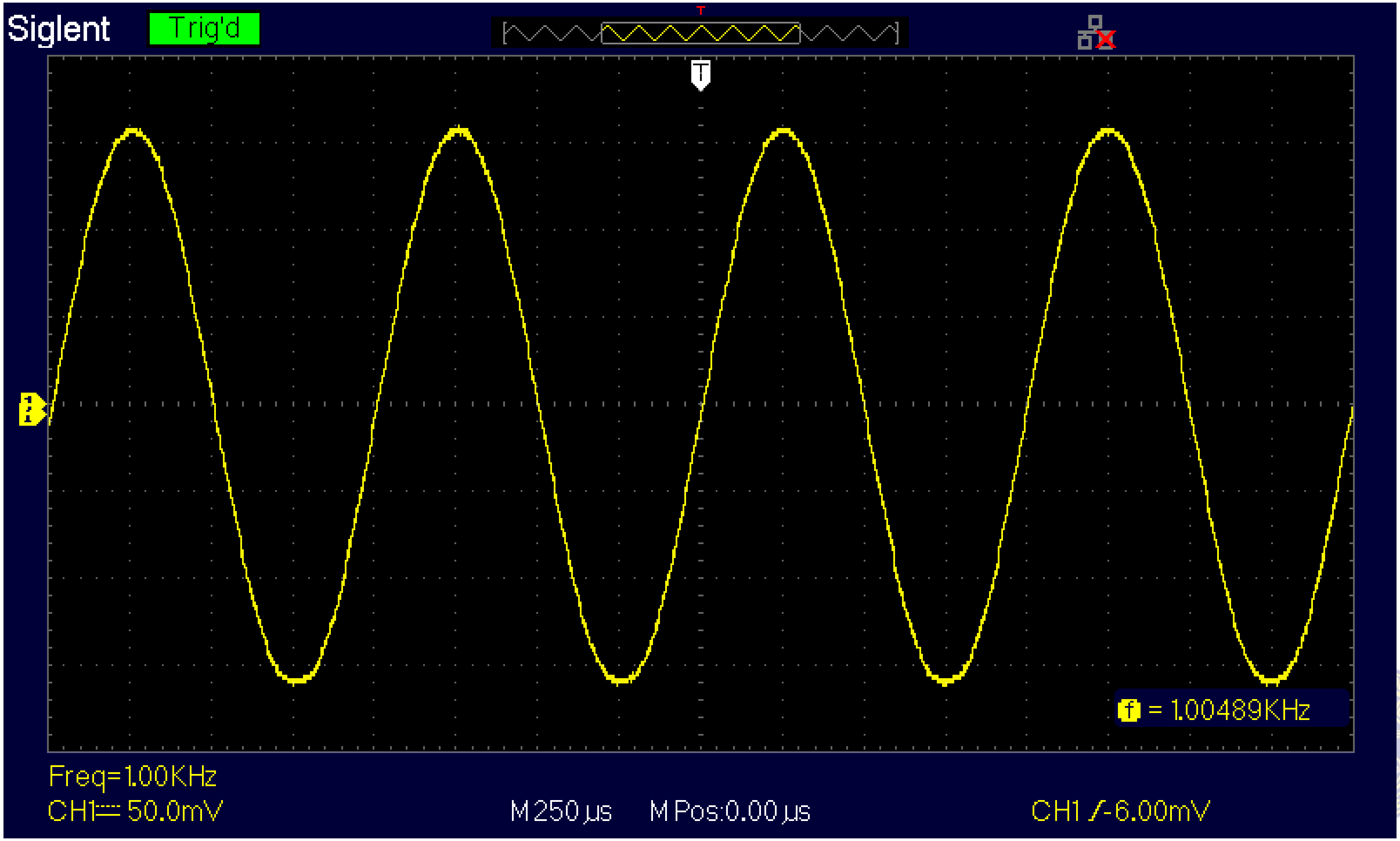


Reading the Oscilloscope



Time base is set to 250µS per division. What is the frequency?

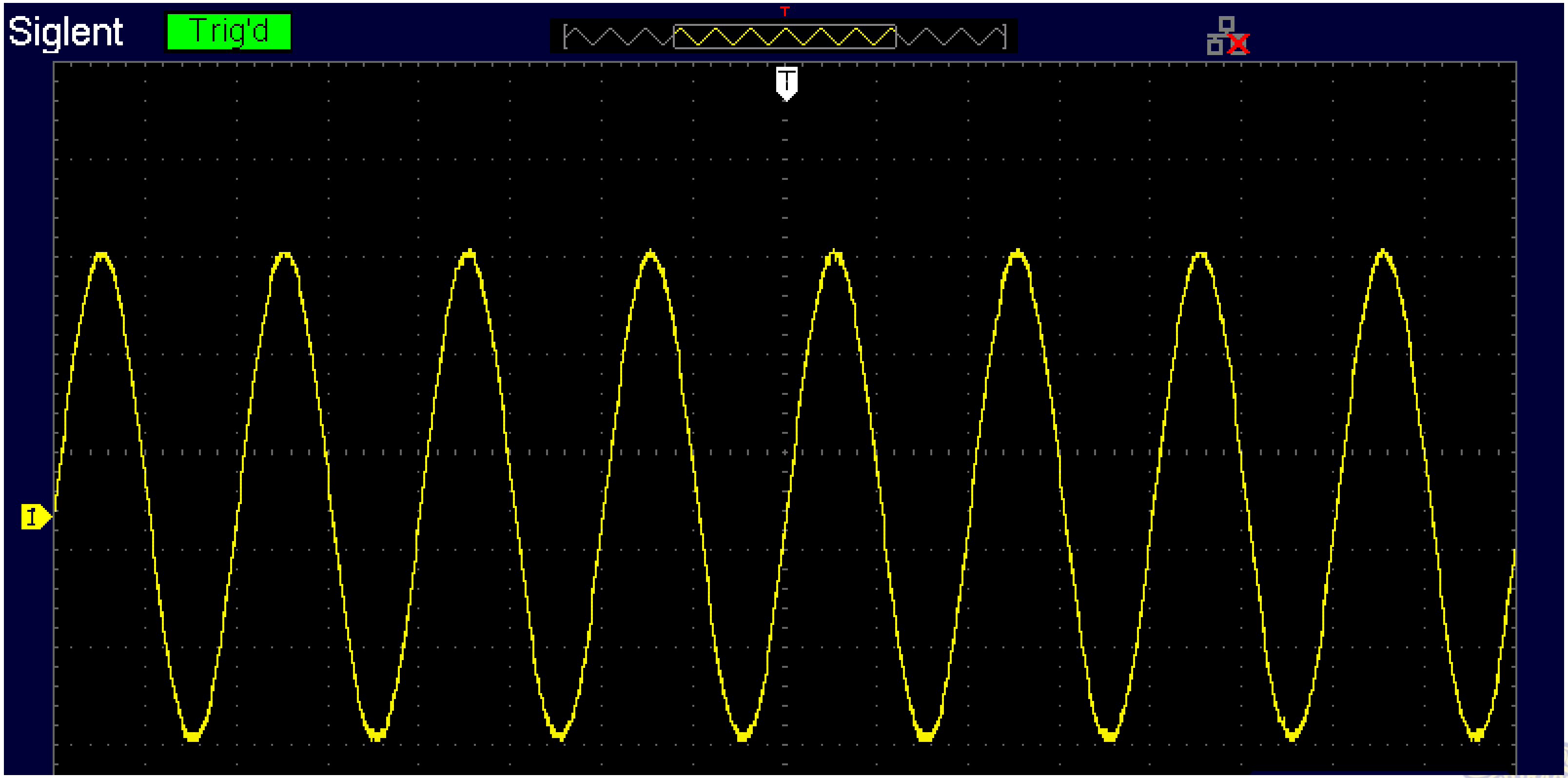
Reading the Oscilloscope



Reading the Oscilloscope

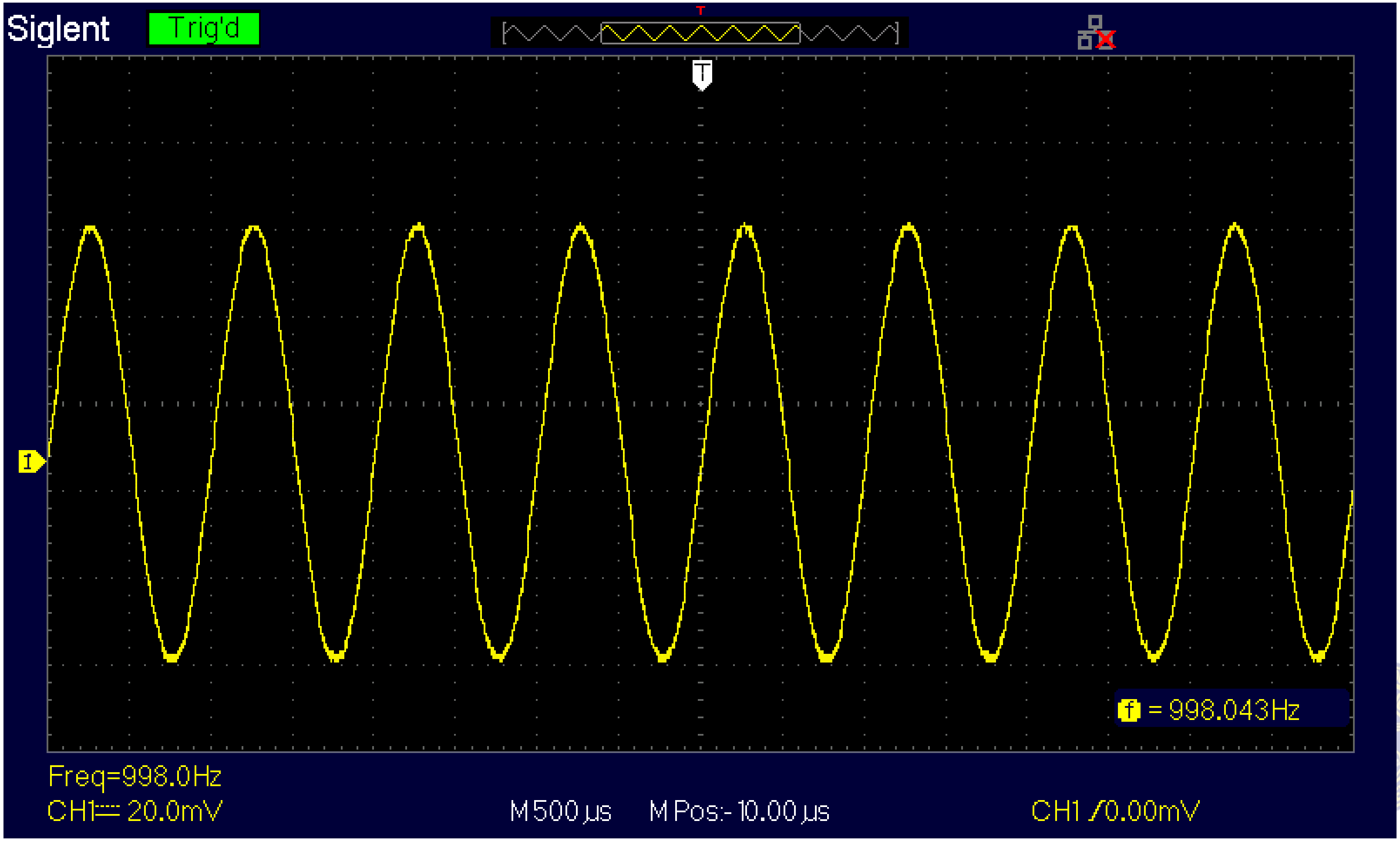
- As can be seen from the previous slides, the exact same waveform can have different appearances depending upon the time base setting of the oscilloscope.
- Select the time base that gives you the best trace depending on your needs in obtaining the trace in the first place.
- If looking for repeatability in a waveform, a higher value may be better, but when examining a single cycle, a lower value rules.

Reading the Oscilloscope

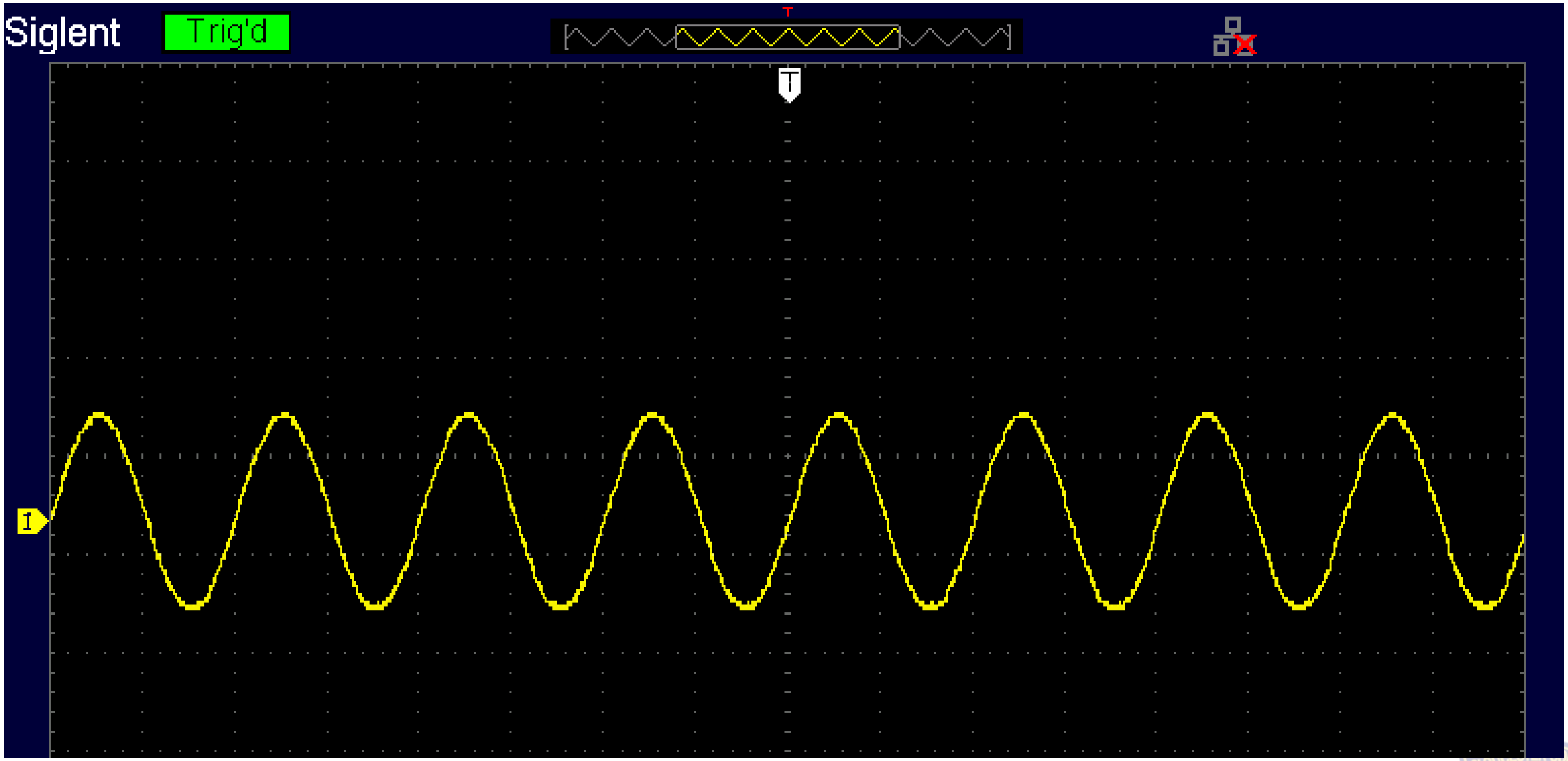


Vertical scale is set to 20mV per division. What is the peak-to-peak voltage?

Reading the Oscilloscope

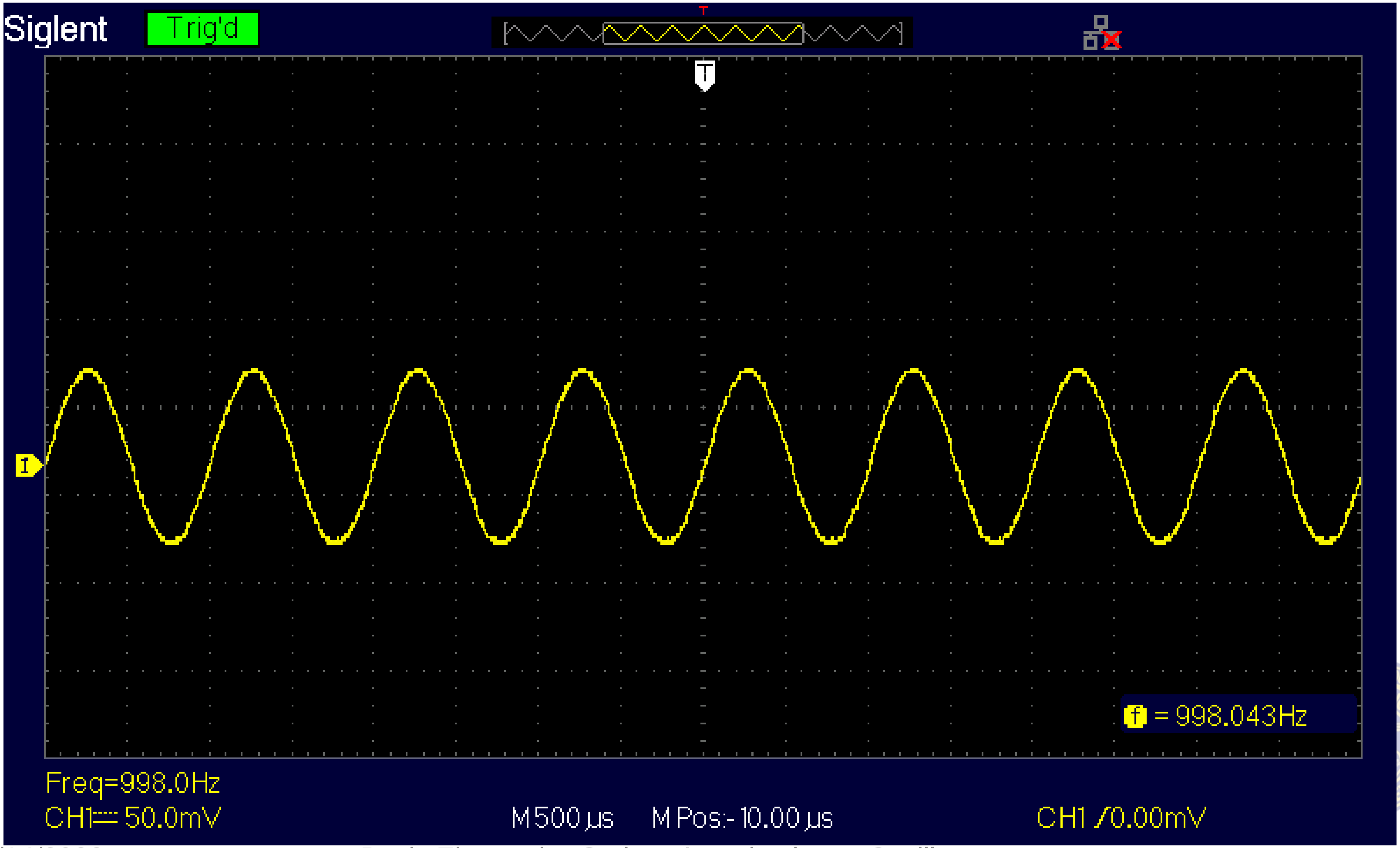


Reading the Oscilloscope

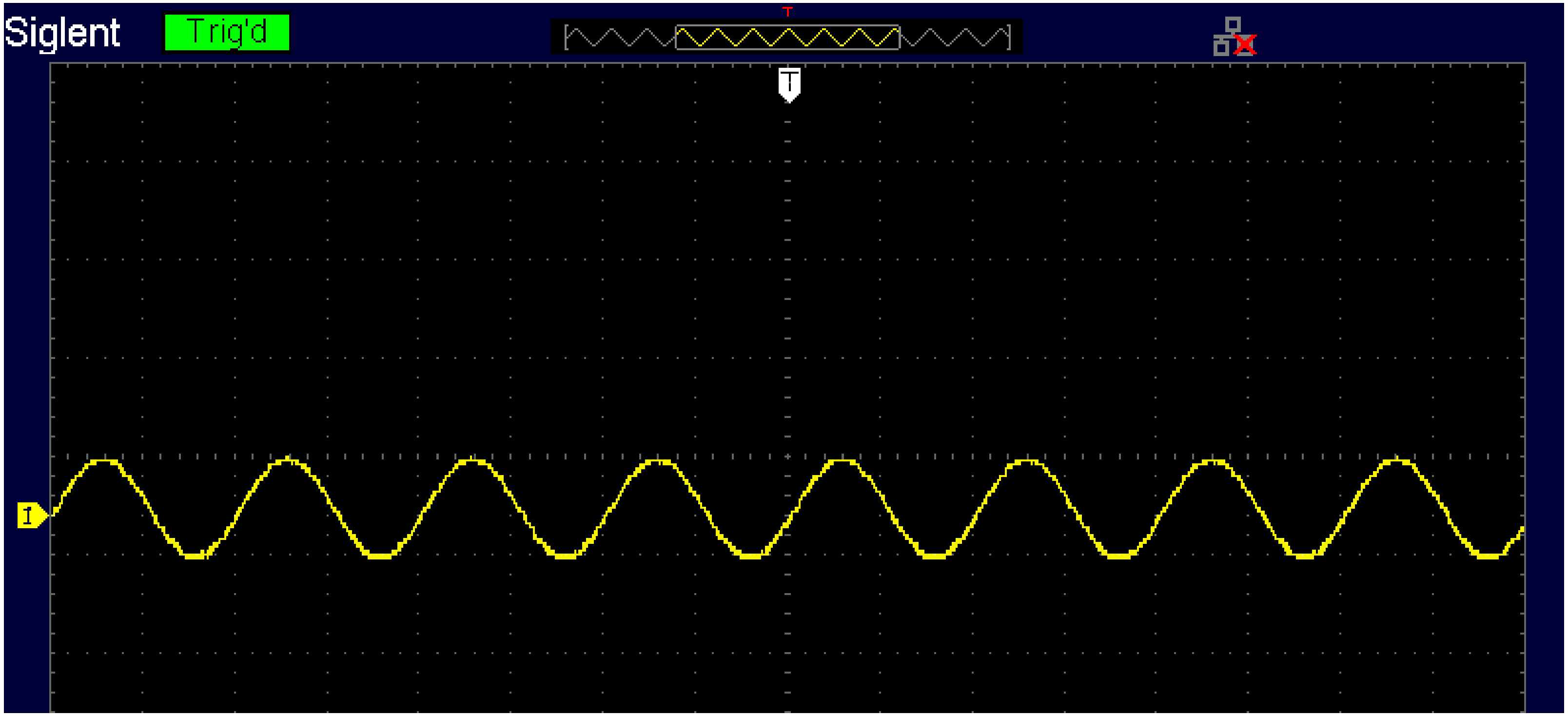


Vertical scale is set to 50mV per division. What is the peak-to-peak voltage?

Reading the Oscilloscope

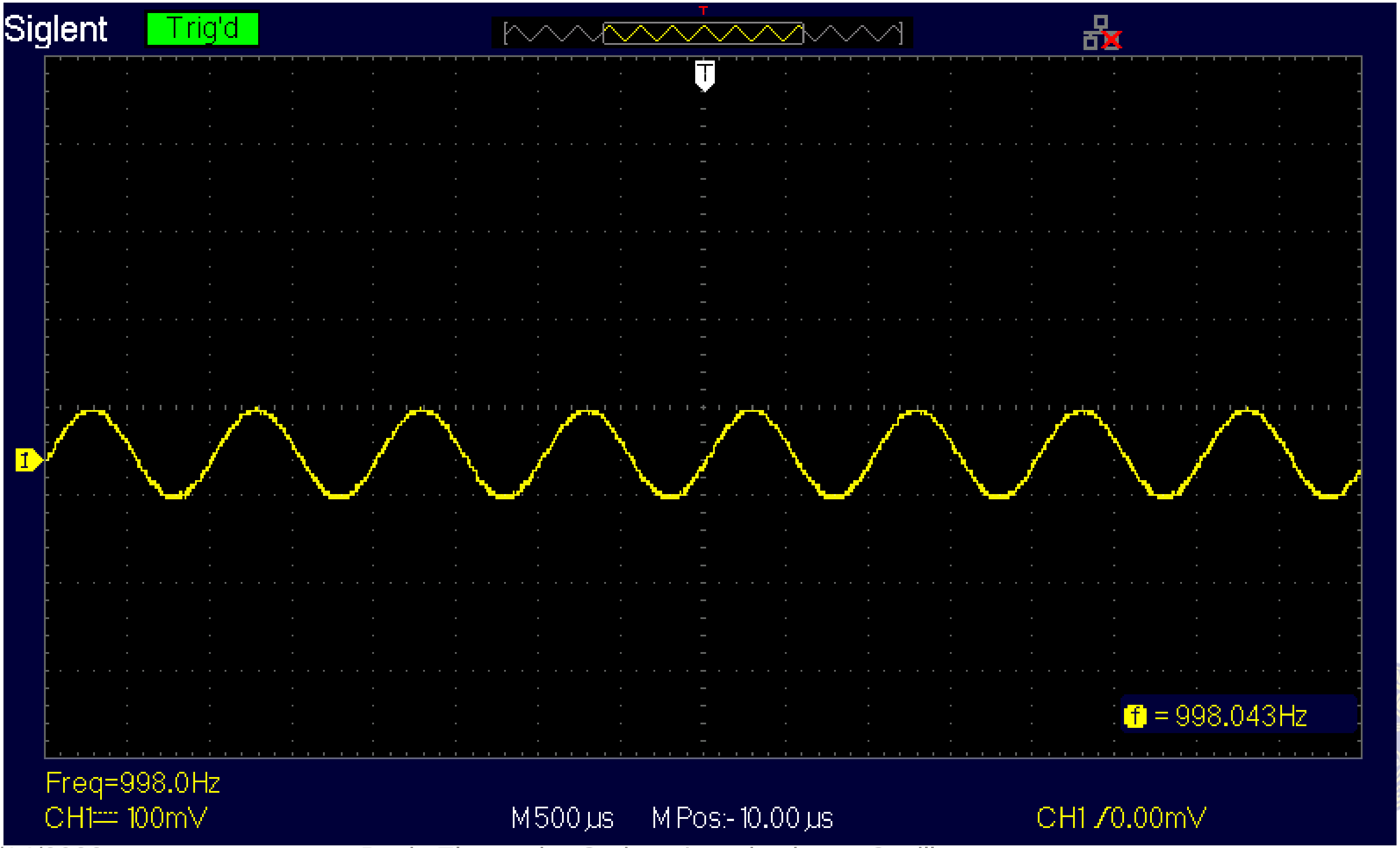


Reading the Oscilloscope

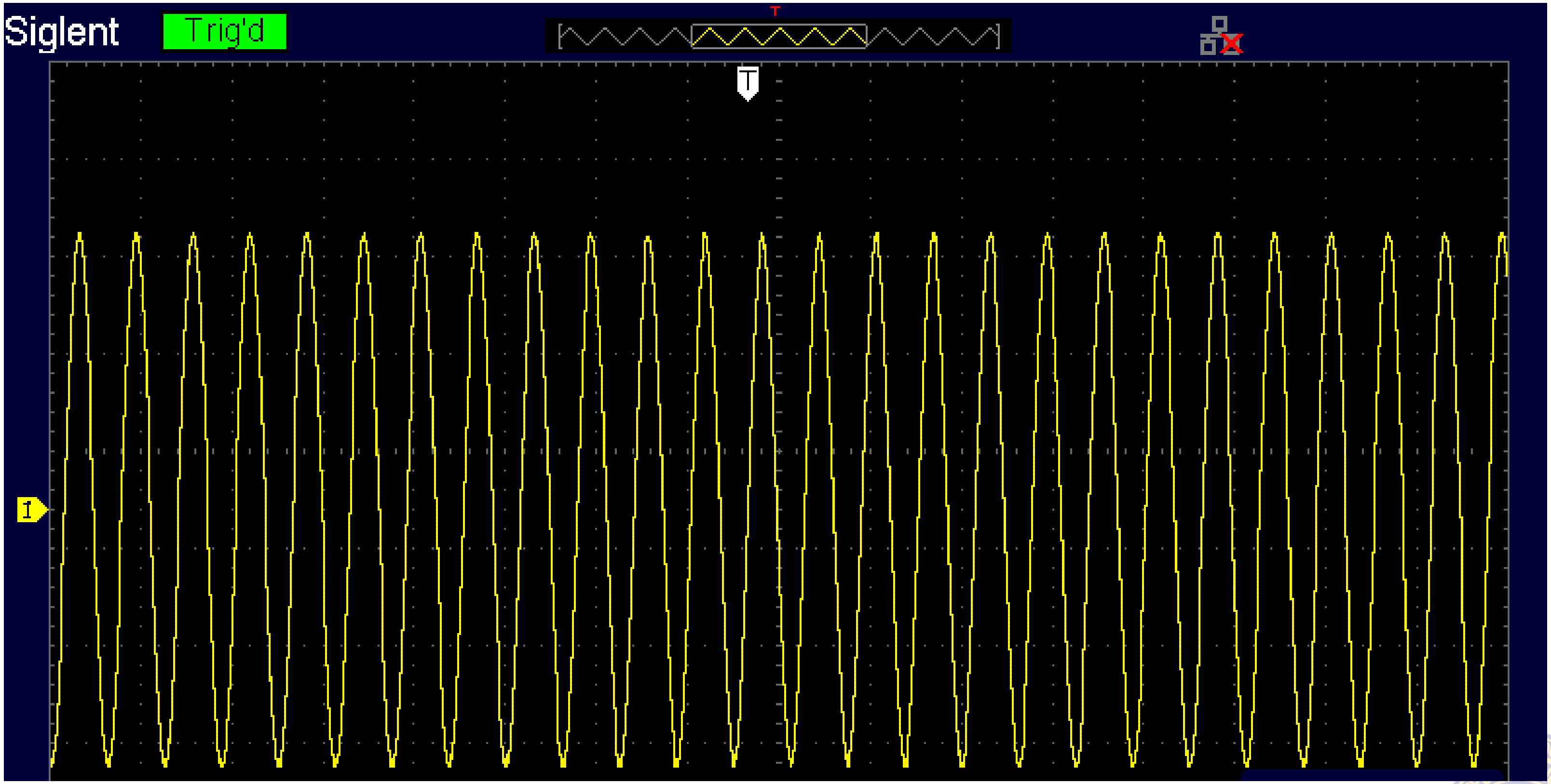


Vertical scale is set to 100mV per division. What is the peak-to-peak voltage?

Reading the Oscilloscope

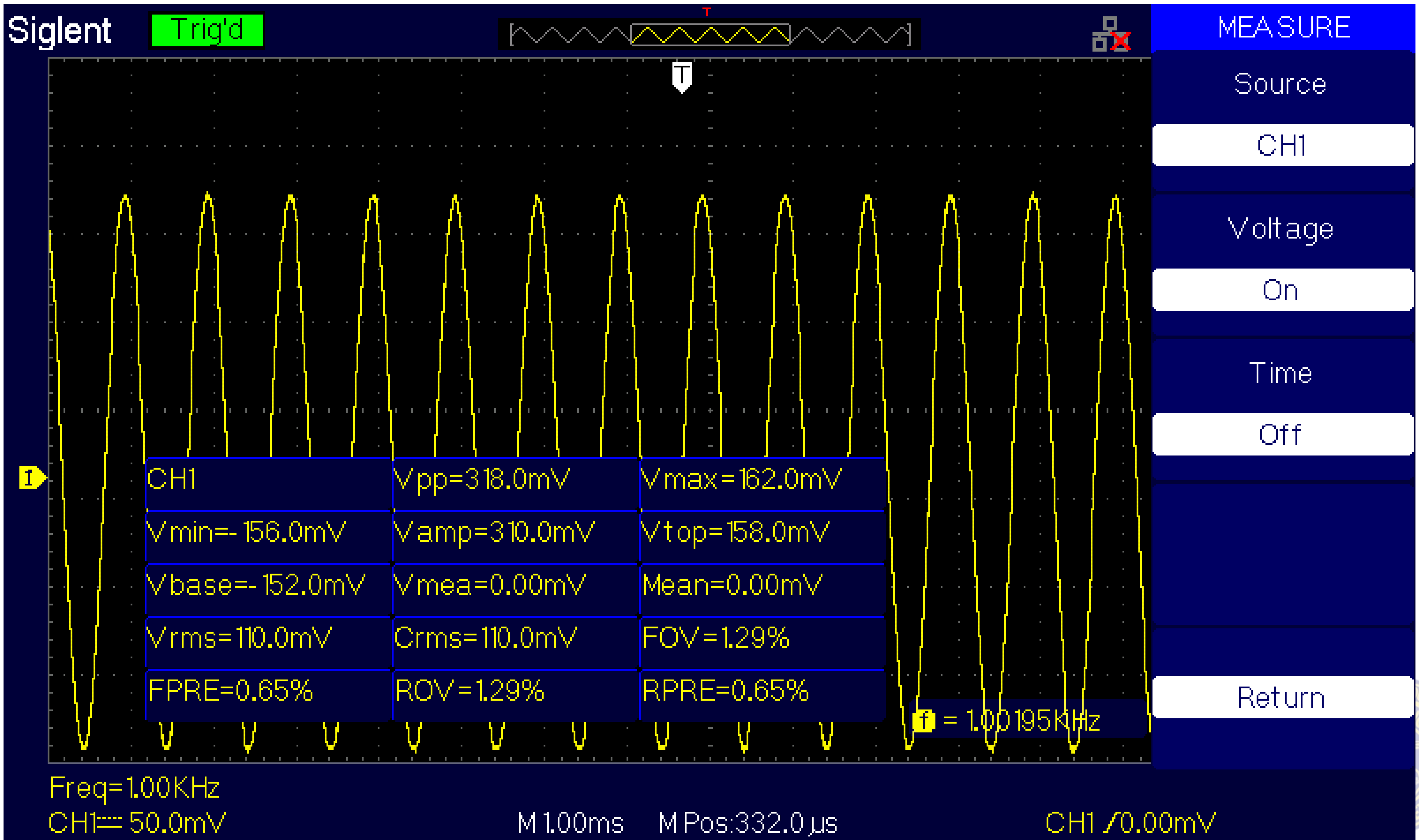


Reading the Oscilloscope

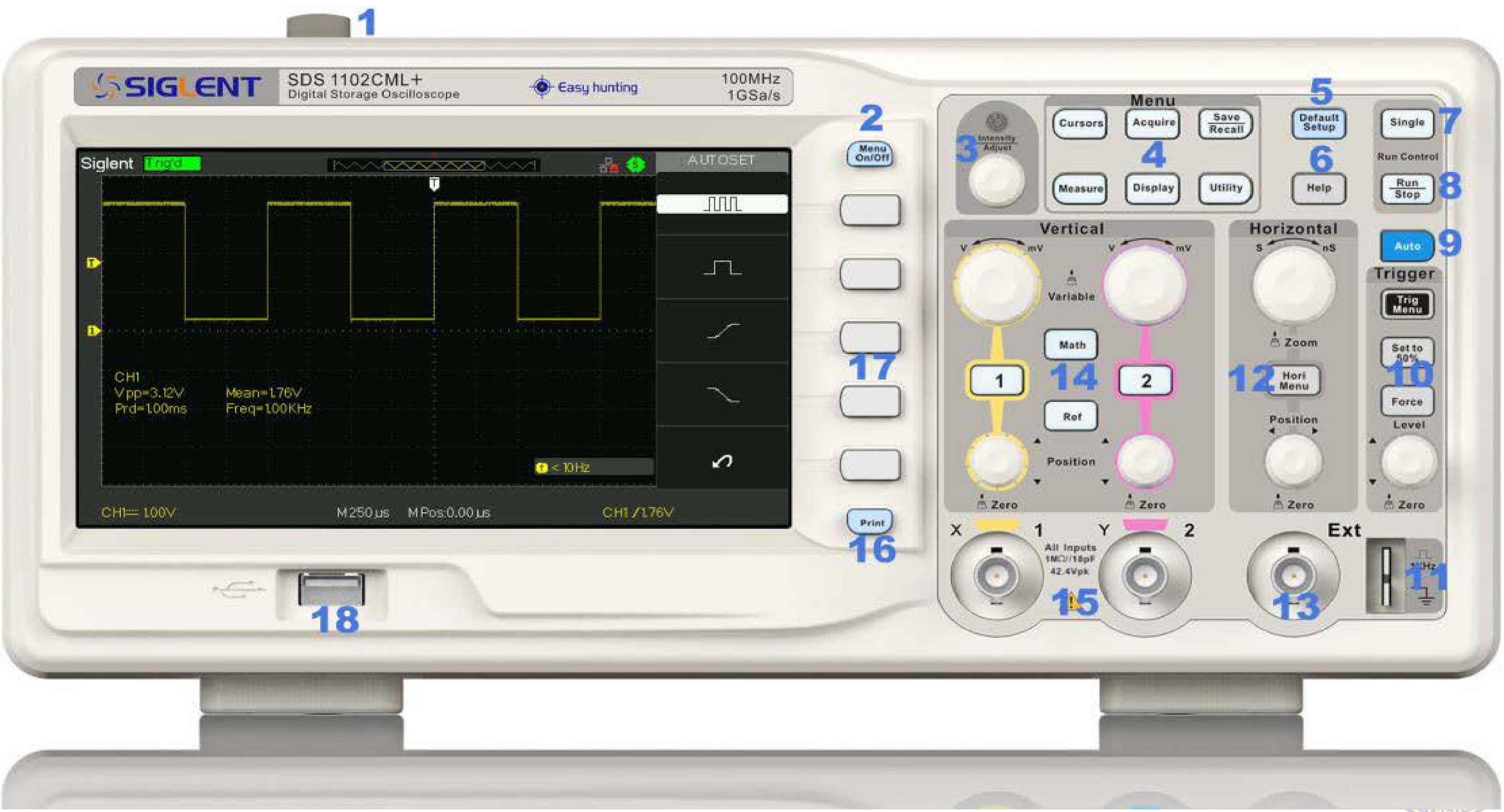


Vertical scale is set to 50mV per division. What is the peak-to-peak voltage?

Reading the Oscilloscope



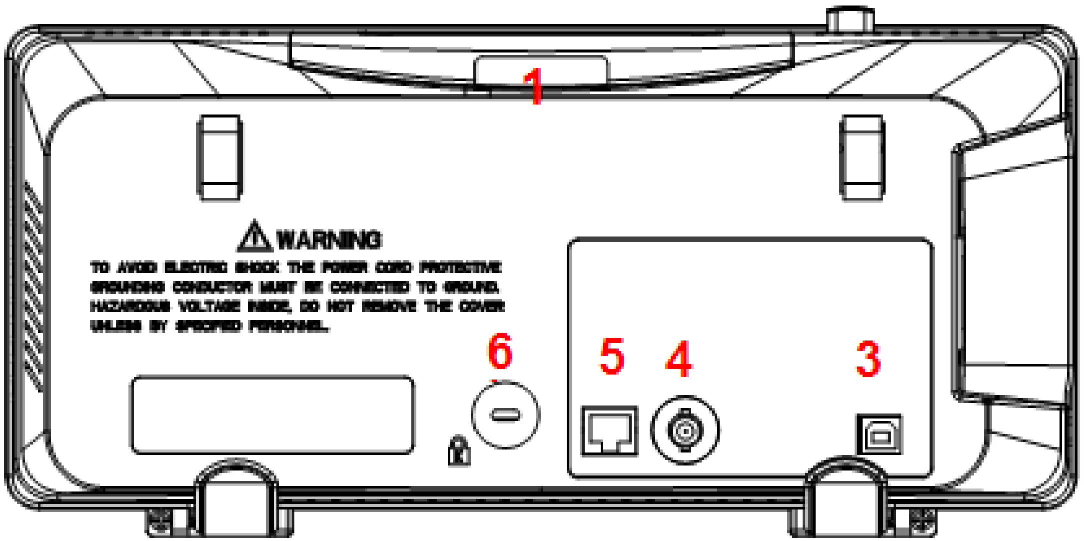
The Siglent SDS1102CML+

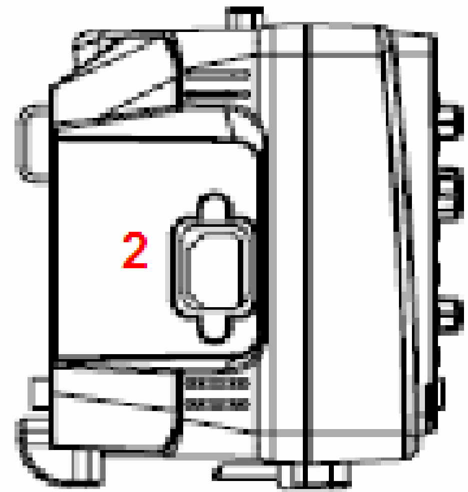


The Siglent SDS1102CML+

No.	Description	No.	Description
1	Power button	10	Trigger Control Area
2	Menu On/Off	11	Probe Compensation
3	Universal Knob	12	Horizontal Control Area
4	Functions Menus	13	Ext Trigger Terminal
5	Default Setup	14	Vertical Control Area
6	Help button	15	Channel Input Terminal
7	Single Trigger	16	Print key
8	Run/Stop Control	17	Menu Softkey
9	Auto Setup	18	USB Host

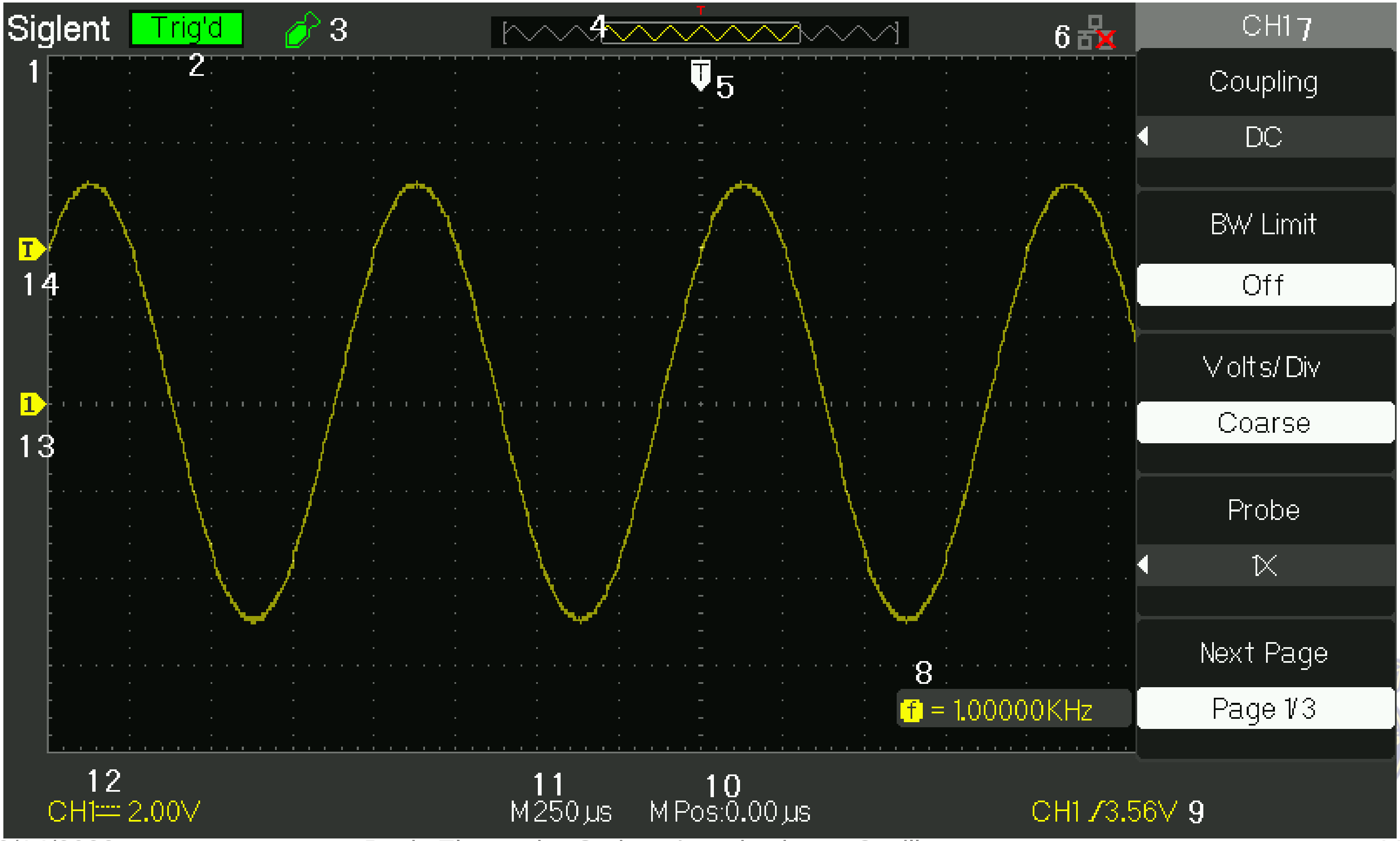
The Siglent SDS1102CML+





1. Handle
2. AC Power Input Terminal
3. USB Device Connector
4. Pass/Fail Output Connector
5. LAN Port
6. Lock Hole

The Siglent SDS1102CML+



The Siglent SDS1102CML+

1. Product Logo

Siglent is the registered trademark of our company.

2. Trigger status

Armed. The oscilloscope is acquiring pre-trigger data. All triggers are ignored in this state.

Ready. All pre-trigger data has been acquired and the oscilloscope is ready to accept a trigger.

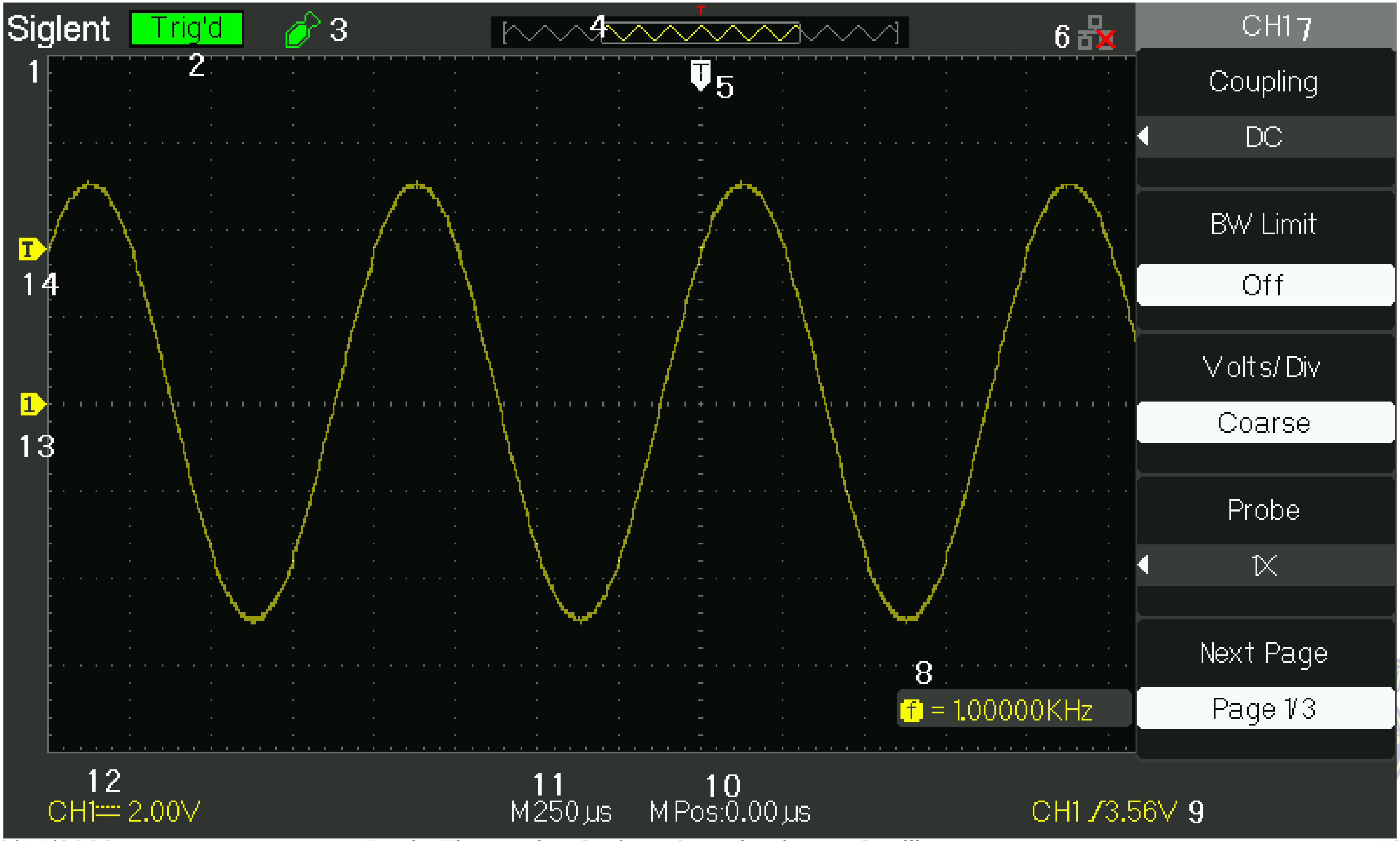
Trig'd. The oscilloscope has seen a trigger and is acquiring the post-trigger data.

Stop. The oscilloscope has stopped acquiring waveform data.

Auto. The oscilloscope is in auto mode and is acquiring waveforms in the absence of triggers.

Scan. The oscilloscope is acquiring and displaying waveform data continuously in scan mode.

The Siglent SDS1102CML+



The Siglent SDS1102CML+

3. USB Host connected mark.

4. Waveform memory.

Shows the position of the current waveform in the memory of the oscilloscope.

5. Trigger position.

Turn the HORIZONTAL POSITION knob to adjust the trigger position of the waveform.

6. Shows the LAN port.

Indicates the LAN port is connected.

Indicates the LAN port is disconnected.

7. Shows the Channel symbol.

8. Readout shows trigger signal frequency.

9. Readout shows the trigger level value and trigger type.

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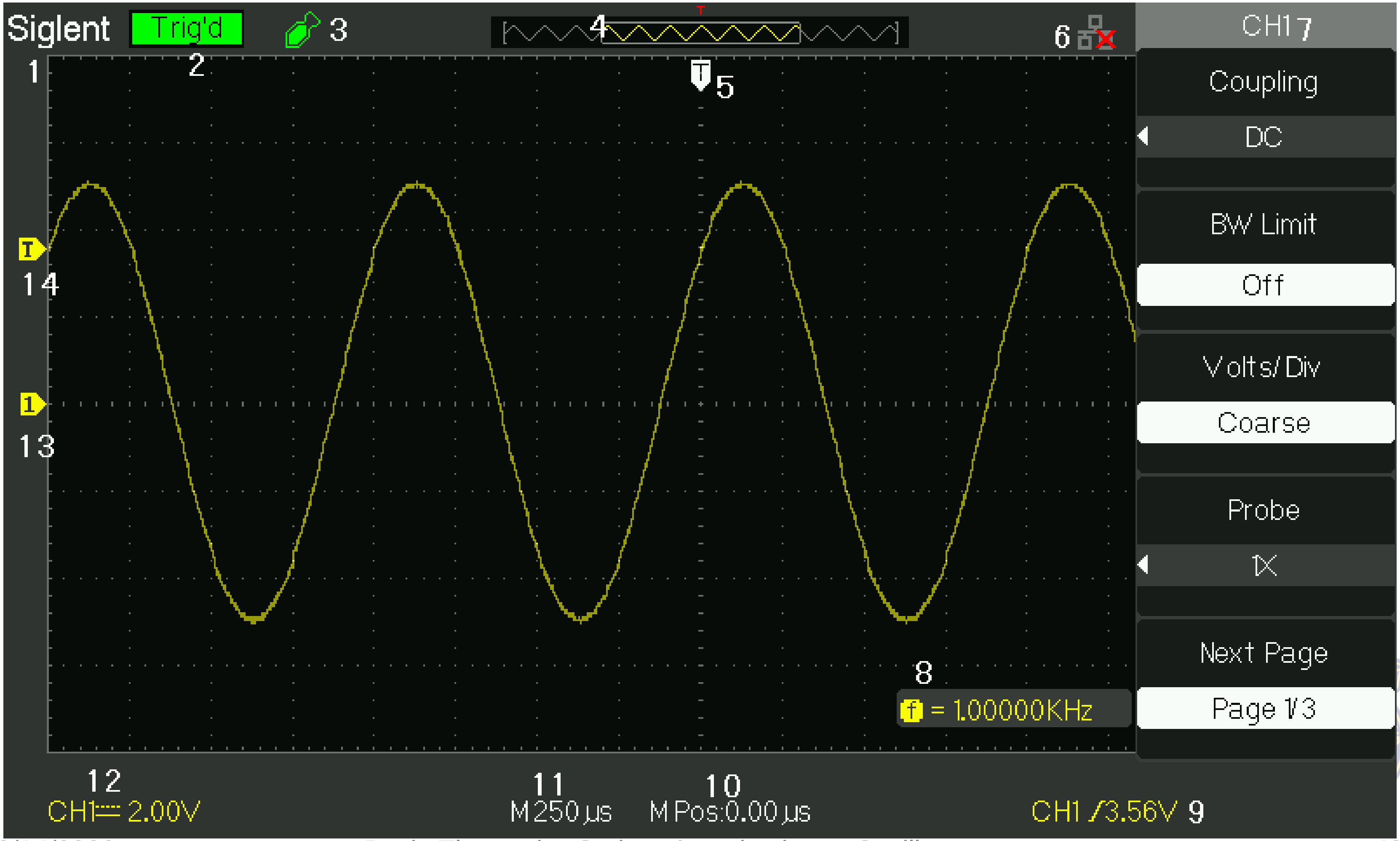

The Siglent SDS1102CML+

10. Readout shows the trigger delay of waveform.
11. Readout shows the main time base setting.
12. Icon shows the channel setting.
13. Icon shows the channel offset position.
14. Icon shows the trigger level position.

Questions?