The Tektronix TDS 220 Oscilloscope
A Very Brief Introduction

A Tektronix TDS 220 two-channel digital oscilloscope ("scope" or "Oscope" for short) is pictured below with its controls grouped for easy recognition in the discussion that follows.

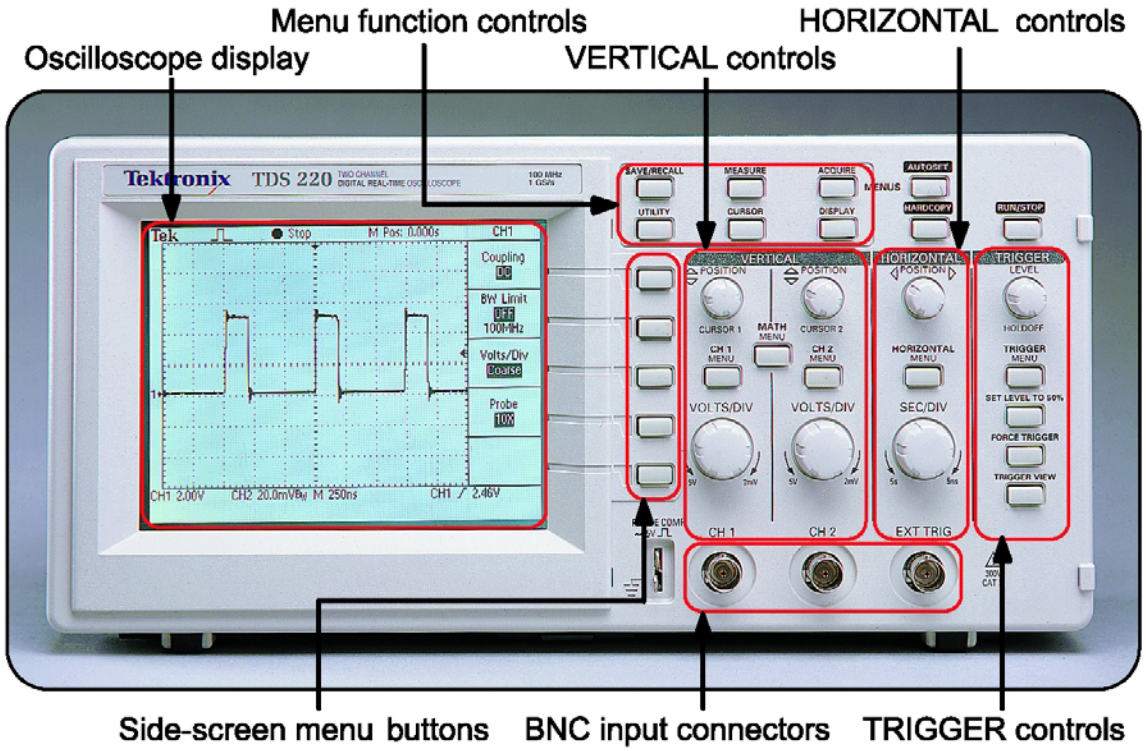


Figure 1: Front panel of a Tektronix TDS 220 oscilloscope.

1. Oscilloscope display

The LCD display replaces the cathode-ray tube used in older oscilloscopes. It adds digital readouts of various settings and menu options. The example shown here displays only Channel-1 on a voltage scale of 2 Volts per division (as indicated by **CH1 2.00V** in the bottom-left corner of the display). The digit "1" with the arrow along the left edge indicates the zero base line for the voltage of Channel 1. The time scale is set at **250 ns** (250 nano-seconds or 2.5X10^{-7}seconds) per division. Since there are 10 divisions from left to right, the display shows a total time of 2.5 μs (2.5 micro-seconds). The downward pointing arrow at the middle of the screen's top edge indicates when triggering of the display occurred (on a rising edge of the square wave). The leftward-pointing arrow along the right side of the display indicates the voltage threshold that will trigger a sweep of the trace. The items down the right side of the display indicate the functions of the side-screen menu buttons for the particular menu (**CH1**) currently selected. This particular menu was selected by the **CH 1 MENU** button within the Vertical Controls section. The **DC** coupling mode means that "Direct Current" voltages are fed in (and not blocked as in **AC** coupling). Higher frequencies can be blocked by changing the **BW** (band-width) setting to **ON**. The **10X** probe setting means that the selected probe attenuates the signal by a factor of ten and that the readings on the scope will be adjusted to compensate for this factor.

A second example for the display is shown in Figure 2. Here the same pulse-train signal is fed into both channels. Note the change in the time base.

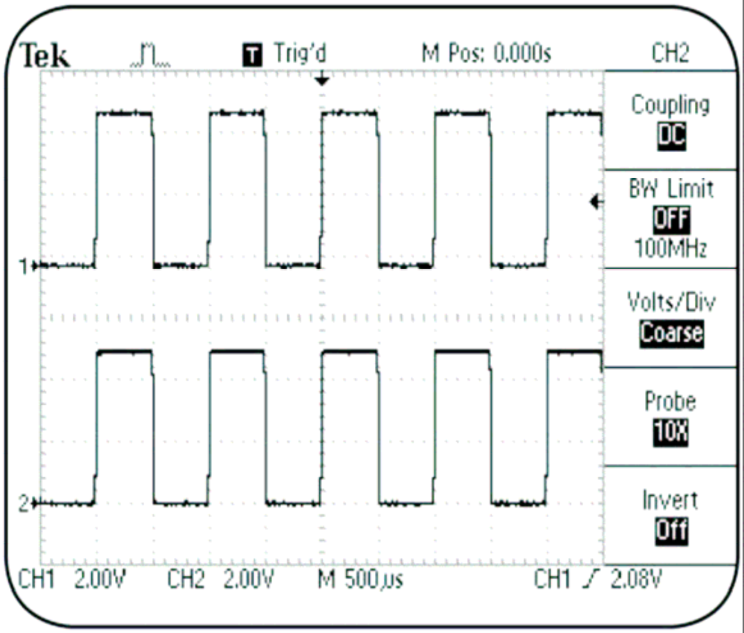


Figure 2: Example of a two-trace display on the TDS 220.

2. Vertical controls

The vertical position and scaling of the traces for the two channels is controlled by the two sets of knobs shown in Figure 3. The **POSITION** knobs adjust the vertical position of the zero voltage level for each channel. (In extreme positions, the traces can be moved completely off the display. Beware of this.) The **VOLTS/DIV** (volts-per-division) knobs control the amount of gain applied to the signals and hence determine the vertical axis scales of the display. These values are displayed along the bottom edge of the screen as mentioned above under the display section.

The probe point is attached to the signal source to be measured, and the black wire lead is attached to a suitable ground (usually the ground pin of the same IC to minimize noise pickup). Try adjusting these knobs while observing the effects on the display.

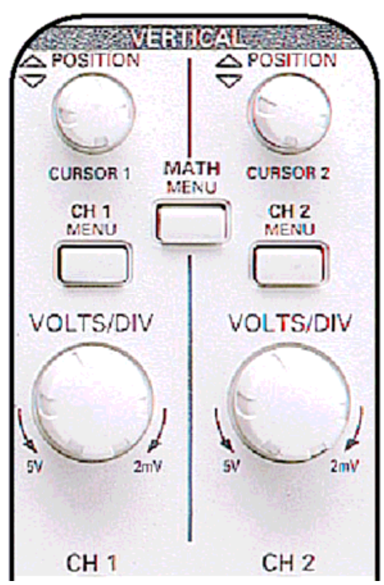


Figure 3: Vertical Controls.

The **CH 1 MENU** and **CH 2 MENU** pushbuttons cause the appropriate input channel menu functions to appear on the side-screen menu and can toggle the channel trace on and off.

3. Horizontal controls

The horizontal position and scaling of the waveform traces are controlled by the two knobs shown in Figure 4. The **POSITION** knob moves the traces left and right on the screen. The **SEC/DIV** (seconds per division) knob sets the time interval between each major grid division (approximately one centimeter) along the horizontal axis of the display. This time interval is common to all channels currently being displayed. It is adjustable from 5 nanoseconds to 5 seconds per division. Finally, the **HORIZONTAL MENU** button selects additional horizontal functions for the side-screen menu.

Warning 1: It is entirely possible to move the traces completely off the screen with the POSITION knob.

Warning 2: Since this is a "sampling" scope, make sure that the time base is properly set to avoid aliasing of high frequency signals.

Figure 4: Horizontal Controls.

4. Trigger controls

Triggering determines when the painting of a trace across the display begins. Triggering can be automatic or forced manually depending on the settings of these controls. Triggering can be repetitive (for periodic waveforms) or produce just a single sweep for single events.

Automatic triggering begins when the input voltage crosses a selected voltage level (determined by the **LEVEL** knob) in the selected direction (either increasing or decreasing as determined by the **RISING EDGE/FALLING EDGE** item in the side-screen menu selected by the **TRIGGER MENU** button). The input voltage used to cause triggering can be either of the input channel signals (**CH 1** or **CH 2** BNC input connectors) or a special signal delivered to the **EXT TRIG** input BNC. The triggering signal can be shown on the display by pushing and holding the **TRIGGER VIEW** button. Improper setting of the trigger controls can result in an overlay of confusing multiple traces, or no trace at all. A wonderful feature of the TDS 220 is the automatic setup feature initiated by the **AUTOSET** button (see Figure 1).

Figure 5: Trigger Controls

Whenever the display is crazy, try pushing this button before calling your TA.

Although the trigger signal determines when the trace is to be displayed, the neat thing about these digital scopes is that this time does not need to correspond to the beginning of the trace. The buffering of the input samples allows the trace on the display to begin before the actual time of the triggering event. The time at which the trigger occurred is marked by a downward-pointing arrow along the top edge of the display, as mentioned earlier.

Manual triggering is initiated by the **FORCE TRIGGER** button.

The **LEVEL** knob serves another function called **HOLDOFF** which sets how much time must elapse before another trigger can occur. The **SET LEVEL TO 50%** button causes the trigger level to be set at the midpoint between the peaks and valleys of the triggering signal.

Another important trigger item selected by the side-screen menu buttons is the source of the triggering signal. Don’t select a source that is not connected!

5. Handy buttons

The cluster of three buttons in the top-right corner of the TDS 220 will prove to be quite useful. The **AUTOSET** button has already been mentioned under Trigger Controls, but it does much more. In fact, whenever you first connect it to a new point on your circuit, you should push **AUTOSET** to have the scope automatically adjust the vertical and horizontal settings as well as the trigger. Then you can optimize the display using the separate vertical and horizontal controls. Since this function selects the lowest numbered active channel for triggering, I recommend that channel 1 be used as the trigger source whenever you are not using the external trigger port.

The **RUN/STOP** button toggles between freezing the display and allowing it to free-run.

The **HARDCOPY** button can send a copy of the display to a printer, if one is connected.

6. Automated measurements using digital readouts

The TDS 220 oscilloscope can produce digital readouts of most of the relevant input signal parameters, including frequency, period, mean (average) voltage, and peak-to-peak voltage. (Note that the “amplitude” of a sine wave is the zero-to-peak voltage, not the peak-to-peak value.) The following steps give an example:

1. Push the **MEASURE** button to see the Measure side-screen menu.
2. Push the top side-screen menu button to toggle the selection to **SOURCE**.
3. Select **CH1** for the sources in the next four menu boxes.

4. Push the top menu button to select **TYPE**.
5. Select **FREQ**, **PERIOD, MEAN** and **PK-PK** for the four measurement types.

The values of the selected items are then shown in the menu and are updated periodically. An example of a display produced with the above setup sequence is shown in Figure 6.

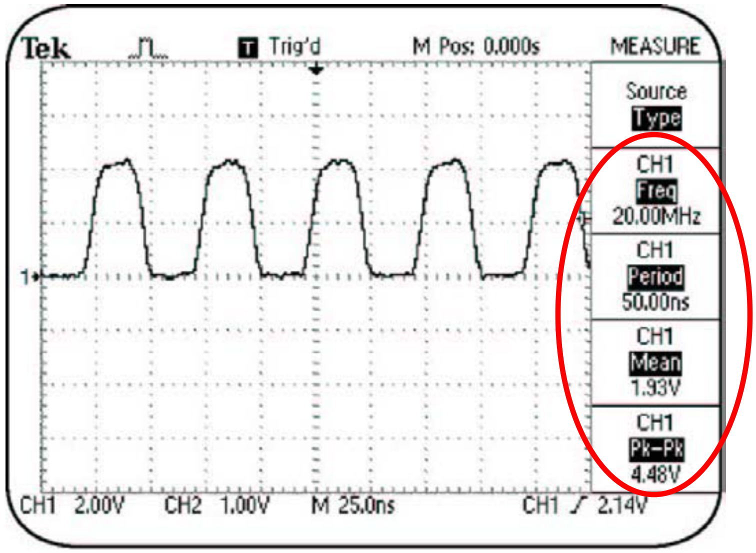
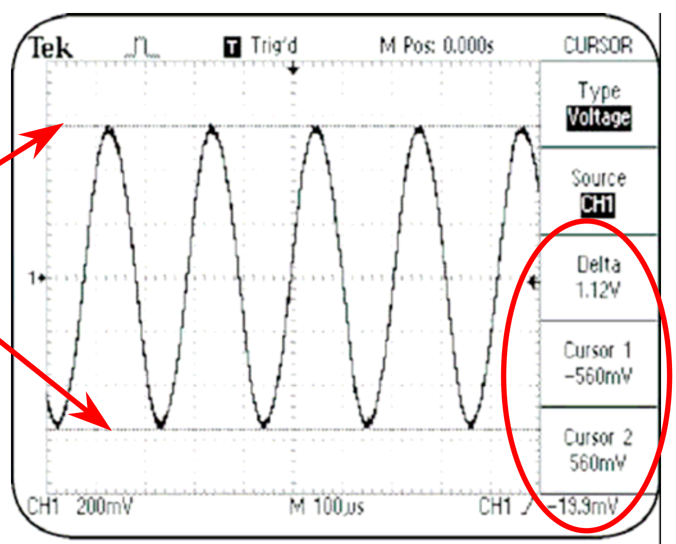


Figure 6: Example of automated measurements with digital readouts.

6. Manual measurements using digital readouts

The TDS 220 can display lines (called cursors) that can be manually placed to measure voltages and times. Suppose you want to measure the peak-to-peak voltage of a sinusoid that has some superimposed noise spikes. You can get a measure of this by setting the cursors (via the upper knobs in the Vertical Controls section) at positions that ignore the noise. (The automated measurement will give the extreme value from the lowest valley to the highest peak.) The peak-to-peak measurement would proceed as follows:

1. Push the **CURSOR** button to see the Cursor menu.
2. Push the top menu button to select **Voltage** (toggling through **Time** and **Off**).
3. Push the Source menu button to select **CH1**.



4. Use the **CURSOR 1** knob to place a cursor at the bottom of the valleys as shown in Figure 7.
5. Use the **CURSOR 2** knob to place the remaining cursor at the top of the peaks.

Figure 7: Voltage measurements using the cursors.

The side-screen Cursor menu now shows:

- The voltage at **Cursor 1**.
- The voltage at **Cursor 2**.
- **Delta** shows the voltage difference between the two cursors, which is the desired peak-to-peak voltage measurement.

Now, suppose you want to measure the time between two events displayed on the scope. Again, you will use the upper knobs in the Vertical Controls section to set the positions of the cursors. Proceed as follows:

1. Push the **CURSOR** button to see the Cursor menu.
2. Push the top menu button to select **Time**.
3. Push the Source menu button to select **CH1**.
4. Use the **CURSOR 1** knob to place a cursor at the start of the time period to be measured, as shown in Figure 8.
5. Use the **CURSOR 2** knob to place the remaining cursor at the end of the time period.

The side-screen Cursor menu now shows:

- The time at **Cursor 1**.
- The time at **Cursor 2**.
- **Delta** shows the time difference, which is the length of the period, and the frequency (reciprocal of the period).

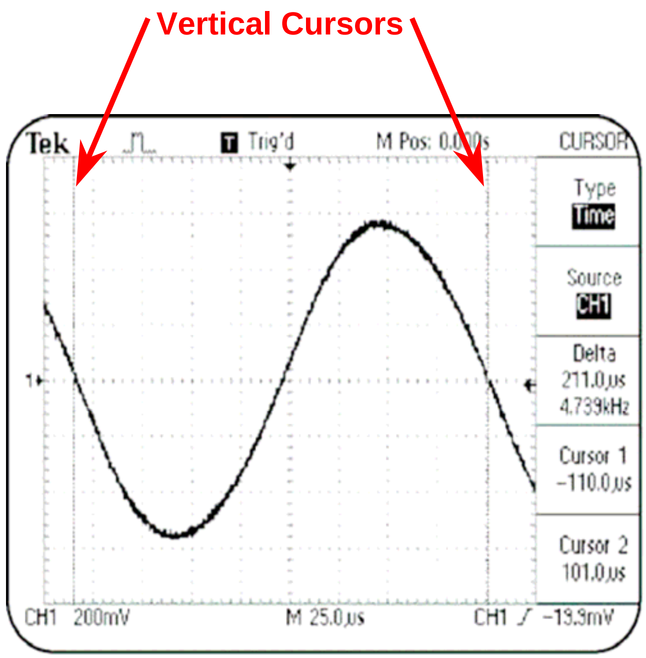


Figure 8: Time measurements using the cursors.

Acknowledgements: My thanks to some unknown author for producing the pictures of the TDS 220 used here.