Oscilloscope Tutorial

Starting Note: Assuming you have your 8-bit counter from lab 0 is programmed into your BTU board, with pin assignments for clock (i.e., it is an input and pulled out) and all output pins (Q0-Q7, RCO) are pulled out.

All references to buttons correspond to the numbering system in the user's manual pages 2-3 through 2-7; please refer to them as necessary.

Before you start

Make sure all calibration knobs (the red ones) are turned into a locked position (clockwise with the arrow). No great force should be needed; you will hear/feel a click when it is locked.

Default positions for knobs you don't need to care about

- Input coupling (#12), labeled "AC GND DC"
  - Set the switch to the right on DC.
- Vertical Mode Switches (#14)
  - BW Limit – out
  - "Add Alt Chop" – set to Alt (middle)
- Invert (#13) – pulled out
- Horizontal Mode (#21) – Set to A (left)
- "Var Holdoff" (#34) – sweep to norm (counter clockwise)
- "P-PAuto" (#26) – Pushed in
- "A Source" (#29) – Set to Int (Up)

Procedure

1) Turn on the oscilloscope by pressing in the black square/power button (# 2). A Green LED will turn on.

   Note: Give the screen a few seconds to warm up. It is ready when you see one or two green horizontal lines. If you do not see anything after ten seconds please consult the trouble shooting section of this tutorial.

2) We will start by using only the Ch 1 probe. In the VERTICAL MODE box (#14) set the left most switch to CH1 (all the way left).
3) Connect the ground clip (the alligator clip on the short wire) for Ch 1 to the ground pin on your BTU board.
4) Connect the probe tip to the output pin that Q3 (the MSB) has been assigned to. Hopefully you see something on the screen that isn't just a horizontal line.
   Note: Make sure the red slider on the probe is set to "x1"
5) CH 1 Volts/DIV (#9) should be set to 1 Volt per division. Since we are using the x1 magnification on the probe, move the 1 on the dial to the 1x bracket labeled on the oscope.
6) Look at the A and B SEC/DIV (#19) knob. Find the nub sticking out which is in between the two black lines on the clear dial. This your time base indicator, now turn it to .5 us (micro)

Oscilloscope Tutorial

NOTE: Pulling out the red calibration knob here will result in a 10x magnification (so that will divide your time base by ten, going from .5us to .05us=50ns). Only use this when needed because it will dim the display, so keep it in for now.

7) Now on screen you should see around eight periods of a square wave. Congratulations!
8) Time to get familiar with some other important components. Take a few moments to experiment with knobs vertical position (#15), horizontal position (#24), CH 1 Volts/DIV (#9), and A and B SEC/DIV (#19).
   What do these knobs do, besides turn?
9) Set CH 1 Volts/DIV (#9) to 1, and A and B SEC/DIV (#19) to .5us.
10) Since you know how to do this now, move the square wave into the upper right quadrant of the display.

Brief Note on triggering: As you hopefully know, an oscilloscope displays a measurement of Voltage vs. Time (vertical and horizontal respectively). A trigger is comprised of a voltage (i.e. 3V, 5V, GND) and a direction (i.e. rising or falling). The scope waits for a trigger to occur before it refreshes the screen.

11) Locate the trigger slope button (#28). This sets the direction of the trigger. When you push this button what happens? Why do you think this occurs? Seriously think about it!
12) Now it's time for you to go solo and add the clock signal to the display. Start this by setting the VERTICAL MODE box's (#14) left most switch to "BOTH" (in the middle). Another horizontal green line should appear.
13) Repeat steps 3-6 for channel two, thus adding the clock signal below Q3. Hint: You will have to use a different setting for your time base.

Draw by hand or take a picture of at least one period of Q3 and all corresponding clock periods. Show this to your TA.

Trouble Shooting

Q: ACK! I can't see anything on my display… it must be busted!

A: No the scope is probably older than you…. It's just fine. Here are some quick scenarios to help speed you along:

- Is the power LED on? If not check both ends of the power cable
- Fiddle with the
  - Vertical Position knobs (#15).
  - Intensity (#8), the fatter part of the knob.
- Check that Horizontal Mode (#21) is set to A.
- Is the trigger LED (labeled as "TRIG'D") on or blinking?
  If not then:
  - Check that the "P-P Auto" (#25) is pushed in
  - Fiddle with the Trigger LEVEL Knob (#27)
  - Is "A Source" (#29) set to "INT" (up)?
  - Is "A&B INT" (#30) set to the trigger channel?
- Push in the Beam Find button (#6).

- This is a very sloppy "Fit to window" command that will give you an idea of where your signal is hiding.
- While holding the button down use the vertical and horizontal position knobs to bring your signal to the center of the screen.

Q: I see something… but it doesn't look pretty.
A: This happens to the best of us, here's what you can do:

- Ground –
  - Check your ground connections, it probably got knocked loose or is a bad soldering job.
  - Are you using a common ground? This is only a problem if you are using a circuit outside of the BTU board.
- Focus – Play with the focus knobs or get a different prescription on your glasses.
- Probe connection –
  - Make sure it is locked into place on the scope.
  - Check the red slider; put it in the "x1".

- Volts/Div – Start big and work your way down until you see something. In this course we will rarely use anything under .5V/Div.

Oscilloscope Tutorial

CONTROLS, CONNECTORS, AND INDICATORS

The following descriptions are intended to familiarize the operator with the location, operation, and function of the instrument's controls, connectors, and indicators.

POWER, DISPLAY, AND PROBE ADJUST

Refer to Figure 2-3 for location of items 1 through 8.

(1) **Internal Graticule**—Eliminates parallax viewing error between the trace and graticule lines. Rise-time amplitude and measurement points are indicated at the left edge of the graticule.

(2) **POWER Switch**—Turns instrument power on and off. Press in for ON; press again for OFF.

(3) **Power Indicator**—An LED that illuminates when power is available to the instrument and the POWER switch is set to ON (button in).

(4) **FOCUS Control**—Adjusts for optimum display definition.

(5) **PROBE ADJUST Connector**—Provides an approximately 0.5-V, negative-going, square-wave voltage (at approximately 1 kHz) that permits an operator to compensate voltage probes and to check operation of the oscilloscope vertical system. It is not intended for verifying the accuracy of the vertical gain or time-base circuitry.

(6) **BEAM FIND Switch**—When held in, compresses the display to within the graticule area and provides a visible viewing intensity to aid in locating off-screen displays.

(7) **TRACE ROTATION Control**—Screwdriver adjustment used to align the crt trace with the horizontal graticule lines.

(8) **A and B INTENSITY Controls**—Determine the brightness of the A and the B Sweep traces.

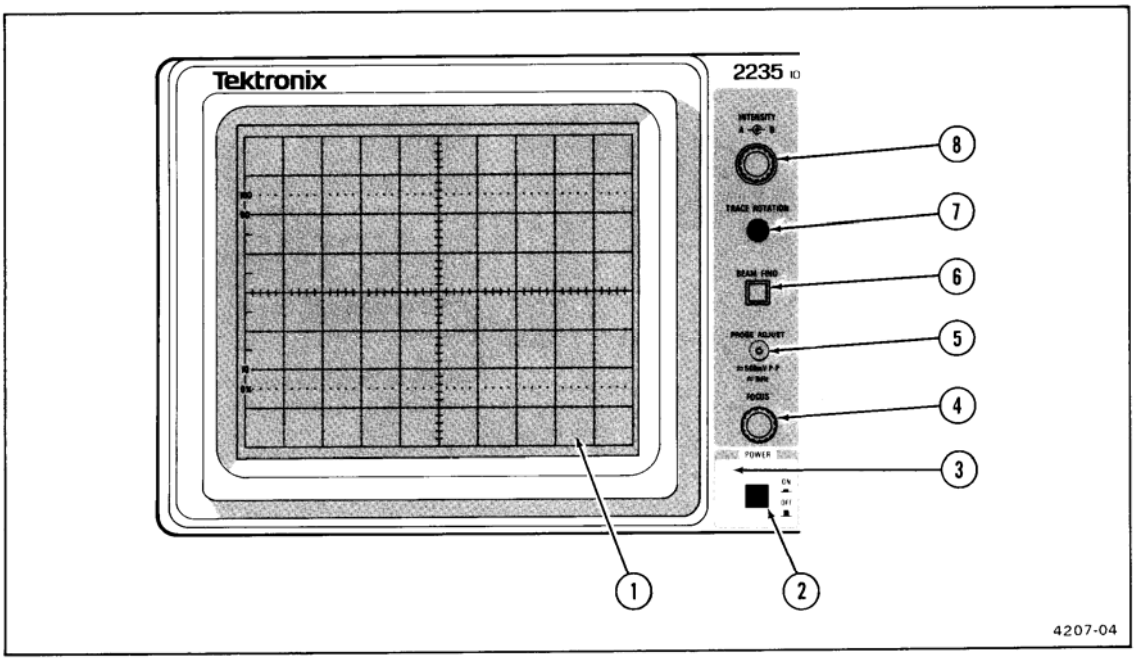

Figure 2-3. Power, display, and probe adjust controls, connector, and indicator.

Oscilloscope Tutorial

VERTICAL

Refer to Figure 2-4 for location of items 9 through 17.

(9) **CH 1 VOLTS/DIV and CH 2 VOLTS/DIV Switches**—Used to select the vertical deflection factor in a 1-2-5 sequence. To obtain a calibrated deflection factor, the VOLTS/DIV variable control must be in the calibrated (CAL) detent (fully clockwise).

1X—Indicates the deflection factor selected when using either a 1X probe or a coaxial cable.

10X PROBE—Indicates the deflection factor selected when using a 10X probe.

(10) **VOLTS/DIV Variable Controls**—When rotated counterclockwise out of their calibrated detent positions, these controls provide continuously variable, uncalibrated deflection factors between the calibrated settings of the VOLTS/DIV switches.

(11) **CH 1 OR X and CH 2 OR Y Connectors**—Provide for application of external signals to the inputs of the vertical deflection system or for an X-Y display. In the X-Y mode, the signal connected to the CH 1 OR X connector provides horizontal deflection, and the signal connected to the CH 2 OR Y connector provides vertical deflection.

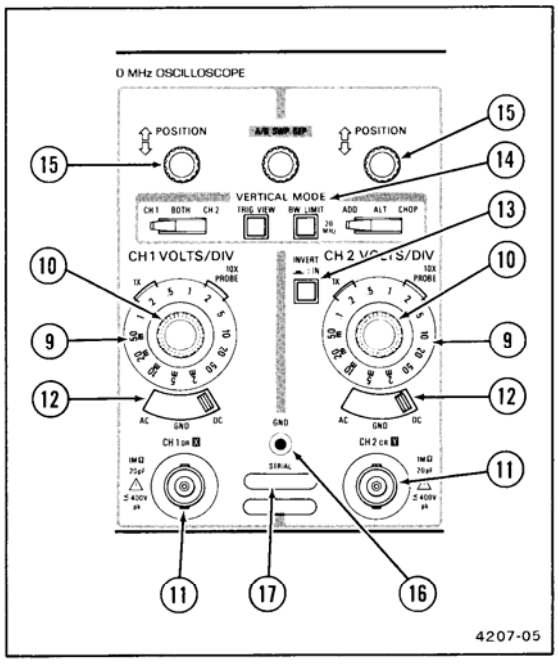

Figure 2-4. Vertical controls and connectors.

(12) **Input Coupling (AC-GND-DC) Switches**—Used to select the method of coupling input signals to the vertical deflection system.

AC—Input signal is capacitively coupled to the vertical amplifier. The dc component of the input signal is blocked. Low-frequency limit (–3 dB point) is approximately 10 Hz.

GND—The input of the vertical amplifier is grounded to provide a zero (ground) reference-voltage display (does not ground the input signal). This switch position allows precharging the input coupling capacitor.

DC—All frequency components of the input signal are coupled to the vertical deflection system.

(13) **INVERT Switch**—Inverts the Channel 2 display when button is pressed in. Push button must be pressed in a second time to release it and regain a noninverted display.

(14) **VERTICAL MODE Switches**—Two three-position switches and two push-button switches are used to select the mode of operation for the vertical amplifier system.

CH 1—Selects only the Channel 1 input signal for display.

BOTH—Selects both Channel 1 and Channel 2 input signals for display. The BOTH position must be selected for either ADD, ALT, or CHOP operation.

CH 2—Selects only the Channel 2 input signal for display.

ADD—Displays the algebraic sum of the Channel 1 and Channel 2 input signals.

ALT—Alternately displays Channel 1 and Channel 2 input signals. The alternation occurs during retrace at the end of each sweep. This mode is useful for viewing both input signals at sweep speeds from 0.05 μs per division to 0.2 ms per division.

CHOP—The display switches between the Channel 1 and Channel 2 input signals during the sweep. The switching rate is approximately 500 kHz. This mode is useful for viewing both Channel 1

Oscilloscope Tutorial

and Channel 2 input signals at sweep speeds from 0.5 ms per division to 0.5 s per division.

TRIG VIEW—Press in and hold this push button to display a sample of the signal present in the A Trigger amplifier (for all A SOURCE switch settings). All other signal displays are removed while the TRIG VIEW push button is held in.

BW LIMIT—When pressed in, this push-button switch limits the bandwidth of the vertical amplifier to approximately 20 MHz. Push button must be pressed a second time to release it and regain full 100-MHz bandwidth operation. Provides a method for reducing interference from high-frequency signals when viewing low-frequency signals.

(15) **POSITION Controls**—Used to vertically position the display on the crt. When the SEC/DIV switch is set to X-Y, the Channel 2 POSITION control moves the display vertically (Y-axis), and the Horizontal POSITION control moves the display horizontally (X-axis).

(16) **GND Connector**—Provides direct connection to the instrument chassis ground.

(17) **SERIAL and Mod Slots**—The SERIAL slot is imprinted with the instrument's serial number. The Mod slot contains any option number that is installed in the instrument.

HORIZONTAL

Refer to Figure 2-5 for location of items 18 through 24.

(18) **A and B SEC/DIV Switches**—Used to select the sweep speeds for the A and B Sweep generators in a 1-2-5 sequence. To obtain calibrated sweep speeds, the A and B SEC/DIV Variable control must be in the calibrated detent (fully clockwise).

A SEC/DIV—The calibrated sweep speed is shown between the two black lines on the clear plastic skirt. This switch also selects the delay time for delayed-sweep operation when used in conjunction with the B DELAY TIME POSITION control.

B SEC/DIV—The B Sweep speed is set by pulling out the (DLY'D SWEEP PULL) knob and rotating it clockwise to a setting opposite the white line scribed on the knob. The B Sweep circuit is used only for delayed-sweep operation.

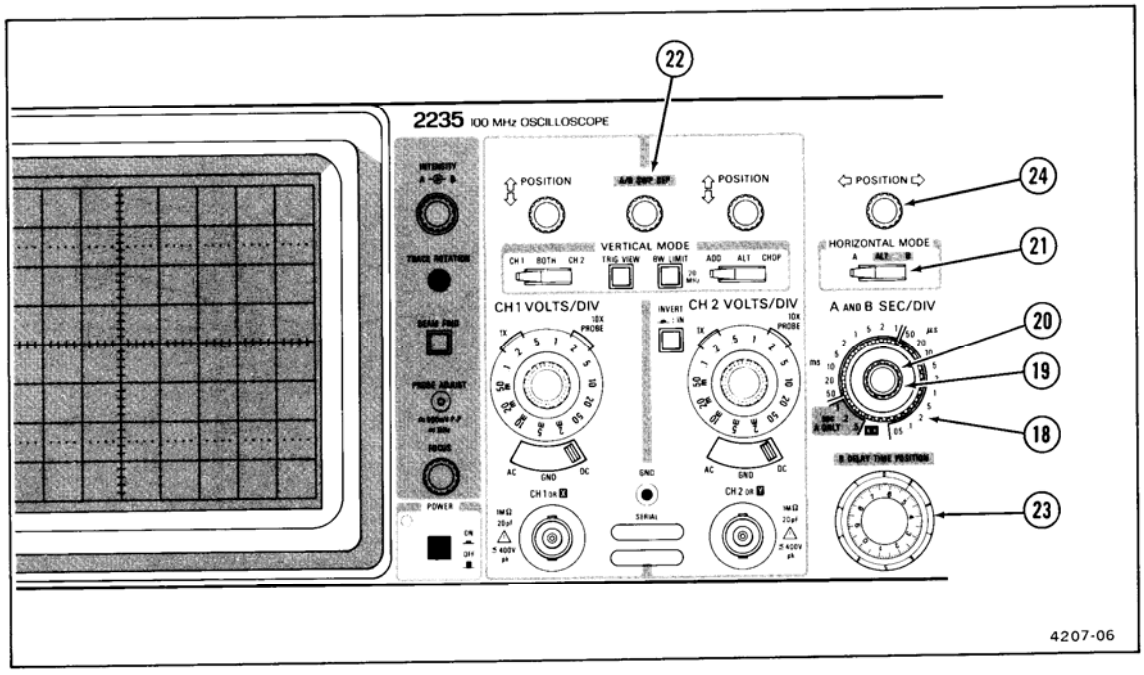

Figure 2-5. Horizontal controls.

Oscilloscope Tutorial

(19) **A and B SEC/DIV Variable Control**—Provides continuously variable, uncalibrated A Sweep speeds to at least 2.5 times the calibrated setting. It extends the slowest sweep speed to at least 1.25 s per division.

(20) **X10 Magnifier Switch**—To increase displayed sweep speed by a factor of 10, pull out the A and B SEC/DIV Variable knob. The fastest sweep speed can be extended to 5 ns per division. Push in the A and B SEC/DIV Variable knob to regain the X1 sweep speed.

(21) **HORIZONTAL MODE Switch**—This three-position switch determines the mode of operation for the horizontal deflection system.

A—Horizontal deflection is provided by the A Sweep generator at a sweep speed determined by the A SEC/DIV switch setting.

ALT—Alternates the horizontal displays between the A Sweep (with an intensified zone) and the B Delayed Sweep. The A Sweep speed is determined by the setting of the A SEC/DIV switch. The B Sweep speed and the length of the intensified zone on the A Sweep are both determined by the B SEC/DIV switch setting.

B—Horizontal deflection is provided by the B Sweep generator at a sweep speed determined by the B SEC/DIV switch setting. The start of the B Sweep is delayed from the start of the A Sweep by a time determined by the settings of both the A SEC/DIV switch and the B DELAY TIME POSITION control.

(22) **A/B SWP SEP Control**—Vertically positions the B Sweep trace with respect to the A Sweep trace when ALT HORIZONTAL MODE is selected.

(23) **B DELAY TIME POSITION Control**—Selects the amount of delay time between the start of the A Sweep and the start of the B Sweep. Delay time is variable from 0.5 times to 10 times the A SEC/DIV switch setting.

(24) **POSITION Control**—Horizontally positions both the A Sweep and the B Sweep displays and horizontally positions X-axis in the X-Y mode.

TRIGGER

Refer to Figure 2-6 for locations of items 25 through 34.

(25) **A TRIGGER Mode Switches**—Three push-button switches that determine the trigger mode for the A Sweep.

SGL SWP RESET—Press in the spring-return push button momentarily to arm the A Sweep circuit for a single-sweep display. This mode operates the same as NORM, except only one sweep is displayed for each trigger signal. Another sweep cannot be displayed until the SGL SWP RESET push button is momentarily pressed in again to reset the A Sweep circuit. This mode is useful for displaying and photographing either nonrepetitive signals or signals that cause unstable conventional displays (e.g., signals that vary in amplitude, shape, or time).

P-P AUTO-TV LINE—Permits triggering on waveforms having repetition rates of at least 20 Hz and television lines. Sweep free-runs in the absence of an adequate trigger signal or when the repetition rate is below 20 Hz. The range of the A TRIGGER LEVEL control is restricted to the peak-to-peak range of the trigger signal.

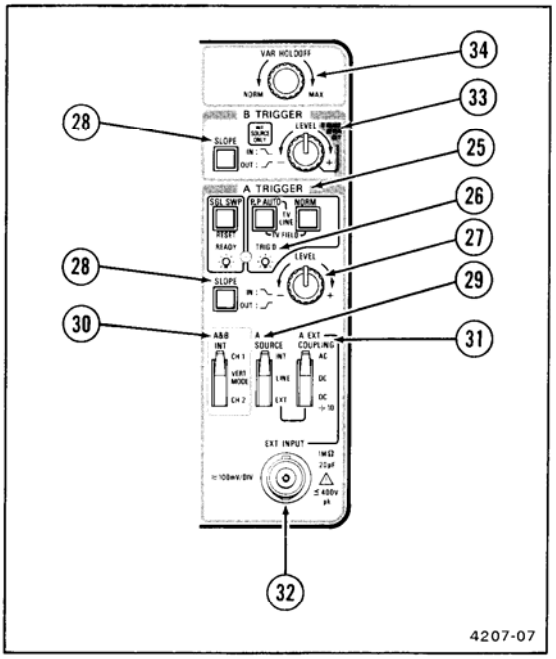

Figure 2-6. Trigger controls, connector, and indicator.

Oscilloscope Tutorial

NORM—Sweep is initiated when an adequate trigger signal is applied. In the absence of a trigger signal, no baseline trace will be present.

TV FIELD—Press in both P-P AUTO and NORM push buttons. Permits triggering on television field signals.

(26) **TRIG'D READY Indicator**—The LED illuminates when either the P-P AUTO or the NORM Trigger Mode is selected to indicate that the A Sweep is triggered (TRIG'D). When the SGL SWP RESET button is momentarily pressed in, the LED illuminates to indicate that the A Trigger circuit is armed (READY) for a single-sweep display.

(27) **A TRIGGER LEVEL Control**—Selects the amplitude point on the trigger signal at which the sweep is triggered.

(28) **SLOPE Switches**—Select the slope of the signal that triggers the sweep.

OUT: ⎍ —When push button is released out, sweep is triggered from the positive-going slope of the trigger signal.

IN: ⎏ —When push button is pressed in, sweep is triggered from the negative-going slope of the trigger signal.

(29) **A SOURCE Switch**—Determines the source of the trigger signal that is coupled to the input of the A Trigger circuit.

INT—Permits triggering on signals that are applied to the CH 1 OR X and CH 2 OR Y input connectors. The source of the internal signal is selected by the A & B INT switch.

LINE—Selects the power-source waveform as the source of the trigger signal. This trigger source is useful when vertical-input signals are time related (multiple or submultiple) to the frequency of the power-source voltage.

EXT—Permits triggering on signals applied to the EXT INPUT connector.

(30) **A & B INT Switch**—Selects the source of the internal triggering signal when the A SOURCE switch is set to INT.

CH 1—The signal applied to the CH 1 OR X input connector is the source of the trigger signal.

VERT MODE—The internal trigger source is determined by the signals selected for display by the VERTICAL MODE switches.

CH 2—The signal applied to the CH 2 OR Y input connector is the source of the trigger signal.

(31) **A EXT COUPLING Switch**—Determines the method used to couple external signals to the A Trigger circuit from the EXT INPUT connector.

AC—Signals above 60 Hz are capacitively coupled to the input of the A Trigger circuit. Any dc components are blocked, and signals below 60 Hz are attenuated.

DC—All components of the signal are coupled to the input of the A Trigger circuitry. This position is useful for displaying low-frequency or low-repetition-rate signals.

DC÷10—External trigger signals are attenuated by a factor of 10. All components of the signal are coupled to the input of the A Trigger circuit.

(32) **EXT INPUT Connector**—Provides a means of introducing external signals into the A Trigger circuit through the A EXT COUPLING switch.

(33) **B TRIGGER LEVEL Control**—Selects the amplitude point on the trigger signals at which the sweep is triggered. When fully clockwise (B RUNS AFTER DLY), the B Sweep circuit runs immediately following the delay time selected by the A SEC/DIV switch and the B DELAY TIME POSITION control.

(34) **VAR HOLDOFF Control**—Provides continuous control of holdoff time between sweeps. Increases the holdoff time by at least a factor of 10. This control improves the ability to trigger on aperiodic signals (such as complex digital waveforms).