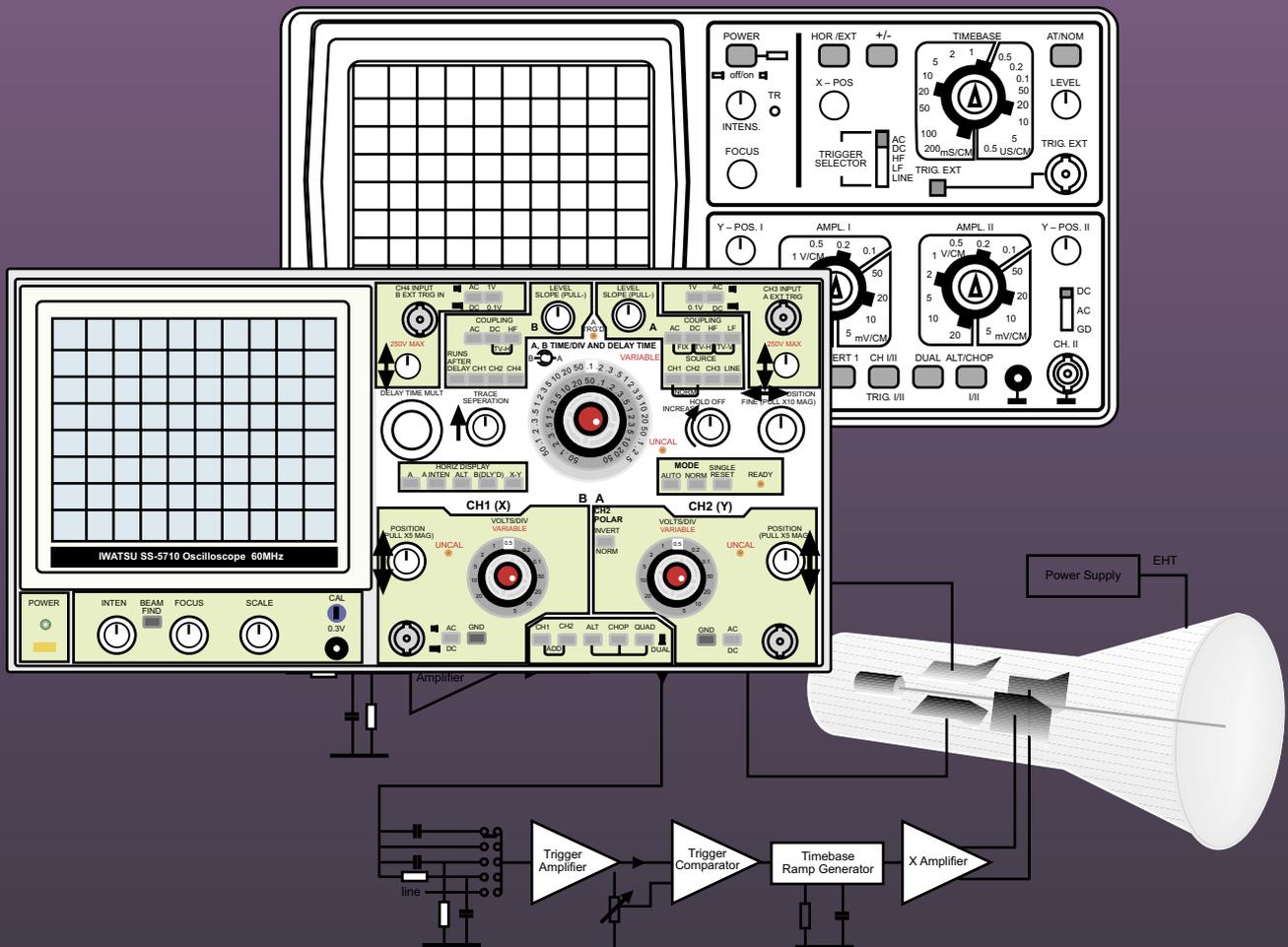


Self Help Guides



Basic Oscilloscope Guide

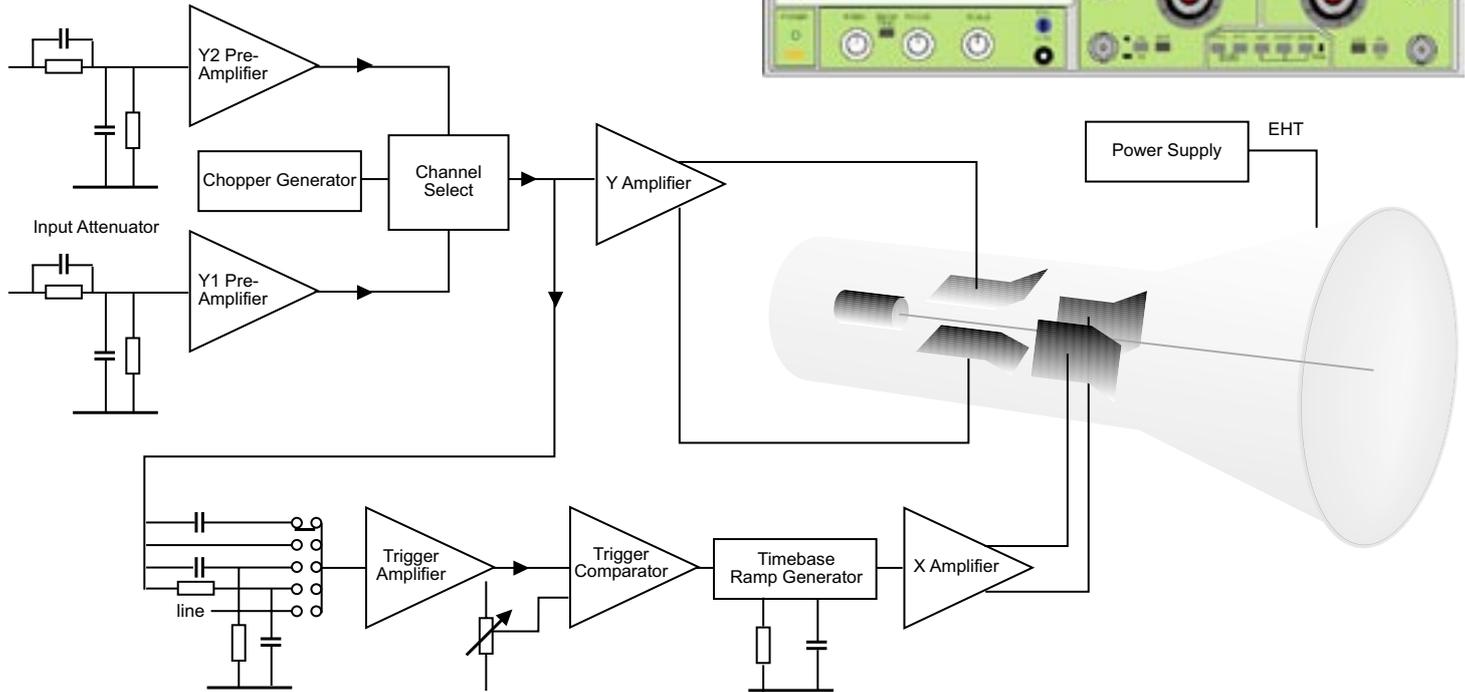
Produced by John Wilmot

OSCILLOSCOPE OPERATION

BASIC OPERATION

The oscilloscope screen consists of a cathode ray tube. Inside the tube is a vacuum. The electron beam emitted by the heated cathode at the rear end of the tube is accelerated and focused by one or more anodes, and strikes the front of the tube, producing a bright spot on the phosphorescent screen.

A simple block diagram is shown below.



The electron beam is deflected, by voltages applied to two sets of plates fixed in the tube. The X-plates produce horizontal movement.

These are connected to the output of the horizontal amplifier.

This amplifier is driven by a ramp waveform generated by the time base generator. As this is a linear ramp whose period can be set from the front panel, the X scale is calibrated in time.

During the rising phase of the sawtooth, the spot is driven at a uniform rate from left to right across the front of the screen. During the falling phase, the electron beam returns rapidly from right to left, but the spot is 'blanked out' so that nothing appears on the screen.

The signal to be measured is applied through a calibrated (frequency compensated) attenuator to the vertical amplifier. This is a wide bandwidth DC pre-amplifier and the output is fed to the vertical deflection amplifier and trigger circuit.

The trigger circuit is used to synchronise the time base to the signal being measured by comparing the level of the input signal to a level set on the oscilloscope trigger comparator.

The signal to be displayed is connected to the input. The AC/DC switch is usually kept in the DC position (switch closed) so that there is a direct connection to the Y-amplifier. In the AC position (switch open) a capacitor is placed in the signal path which blocks DC signals but allows AC signals to pass.

The Y-amplifier is linked in turn to a pair of Y-plates so that it drives the Y-axis of the display.

The overall gain of the Y-amplifier can be adjusted, using the VOLTS/DIV control. The vertical scale is usually given in V/DIV or mV/DIV.

Note:

Many oscilloscopes now use LCD screens instead of Cathode Ray Tubes but the principal is the same, the operation is carried out digitally instead.

CONTROLS

This is a general description of the oscilloscope controls and not intended to be for any particular model.

OSCILLOSCOPE GRATICLE

The face of the oscilloscope shows a grid of lines onto which will be projected a voltage vs. time graph for whatever signal is being studied at the time.

Each block on the grid (squares of about 1 cm in size) is referred to as a division, abbreviated DIV. The vertical axis on the grid represents voltage, and the horizontal axis represents time.

INTENSITY

The intensity control makes the trace brighter or dimmer.

SCALE

The scale illumination adjusts the intensity of the scale brightness.

FOCUS

This focuses the image on the screen and is adjusted to get the display as sharp as possible.

DUAL-TRACE OPERATION

Dual-trace operation allows you to view two independent signal sources. This operation allows an accurate means of making amplitude, phase, time displacement, or frequency comparisons and measurements between two signals.

DUAL-BEAM

Dual-beam oscilloscopes produce two separate electron beams on a single scope, which can be individually or jointly controlled.

ALT/CHOP MODE

Both are used on dual-trace oscilloscopes to complement each other as explained below:

ALT mode

The ALT (alternate) mode of obtaining a dual trace uses the technique of switching between channel 1 and channel 2 on alternate sweeps.

The ALT mode is not used for slow sweep speeds.

CHOP mode

The output voltage from each amplifier is applied to the deflection plates through an electronic switch. A high-frequency multi vibrator controls switching. The switch selects the output of one channel and then the other at a high-frequency rate (1200 kHz in most oscilloscopes) as the trace sweeps across the screen.

As the sweep frequency becomes lower compared to the chopping frequency, the display will show apparently continuous traces; therefore, the CHOP mode is used at low sweep rates.

VERTICAL CHANNELS

The Channel Input Connector is a BNC type. This single cable contains both the ground and input lines.

Input sensitivity

The VOLTS/DIV knob is the vertical sensitivity knob. With this knob you can specify the scale for the vertical axis of the oscilloscope grid. This control adjusts the gain of the input amplifiers.

GND POSITION:

When the GND position switch is pushed in, the input terminal is isolated from the display and the input of the amplifier shorted to ground. The trace on the display becomes a horizontal line that corresponds to an input that is grounded.

This is only useful when the zero position of the trace requires adjusting using the Trace Vertical Position Control.

DC POSITION:

There may be occasions where the DC Component of a signal would be a hindrance to the accurate measurement of the AC component of the same signal. An example would be measuring the AC ripple on a DC power supply.

The DC setting of the switch simply displays the signal as it is input.

AC POSITION:

The AC switch setting simply removes any DC component from the signal.

Y Position

The knob moves the trace up and down.

You can use this knob to make the trace easier to view, but remember that if you have set a certain position for ground (0 V), then turning this knob will change your 0-V setting.

TIME BASE CONTROLS

The time base generates a ramp waveform which drives the X - Plates and moves the trace horizontally across the screen.

The period of this waveform is determined by the TIME/DIV settings.

X Position

The horizontal position knob moves the trace to the right or left. This control is used to position the trace horizontally to make it easier to see parts of the waveform more clearly.

TIME BASE A

The scale on the horizontal axis (time) is set by the horizontal sweep time control. This control sets the time for each division (DIV).

TRIGGERING

The Sweep Mode control is either in the AUTO(matic) or NORM(al) modes. The AUTO mode allows the trace to free run. The NORM mode holds strictly to the setting of the trigger control.

It's usually a good idea to start off with the AUTO setting, and then use NORM with the trigger control to set the trigger point manually.

COUPLING

In order to be able to lock onto different types of waveforms, the following options are normally available.

AC

Used to reject DC by blocking it with a capacitor.

DC

Triggers on the DC level, this is normally selected for low frequencies.

LF Reject

Passes the signal through a high pass filter. It can be used to reject mains hum which may be on the signal.

LINE

Triggers on the mains frequency.

TV H

Used to trigger on the field/frame rate of a TV signal.

TV V

Used to trigger on the field/frame rate of a TV signal.

HF Reject

Passes the signal through a low pass filter. This can be useful for rejecting noise.

DUAL-TRACE OSCILLOSCOPE CONTROLS

Some dual-trace oscilloscopes have both an A and B time base for horizontal sweep control.

TIME BASE B

The functions and settings are normally the same as those controls in the A time base section. The main use of two timebases is for Delayed sweep and Alternate sweep.

ALTERNATE SWEEP

In this case there are two traces shown on the screen. One trace is controlled by the A time base and the second by the B time base. In this way you can see an 'expanded' part of the waveform together with a larger part of the waveform at the same time.



DELAYED SWEEP

The purpose of this is to enable close-up examination of an event in a periodic waveform.

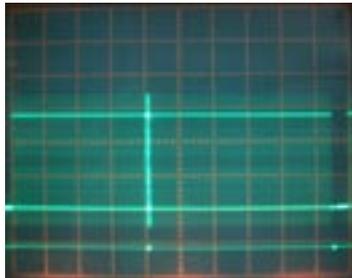
The second time base is triggered after the setting of the B time base multiplied by the value on the vernier of the Multiplier.

MULTIPLIER

This variable multiplier is normally in the form of a 10-turn potentiometer with a vernier scale.

This allows the delay before the second time base (B) triggers to be set by the value of the vernier setting multiplied by the setting of the second time base.

When the horizontal display is set to A Intensified by B, the trace shows the waveform scanned at the rate set by time base A. The point at which the delay occurs is shown by the intensified part of this trace. The duration of the intensified portion is determined by the setting of time base B.



When the horizontal display is set to B Delayed, then the highlighted part of the previous screen will be displayed.

Uses

A good example of this is to pick out an individual line of an analogue TV signal.

The first time base is triggered at field rate and the second time base set to line rate. The multiplier can then be used to run through each line in sequence.



STORAGE SCOPES

These can be analogue or more commonly now digital. They are useful for measuring single shot events.

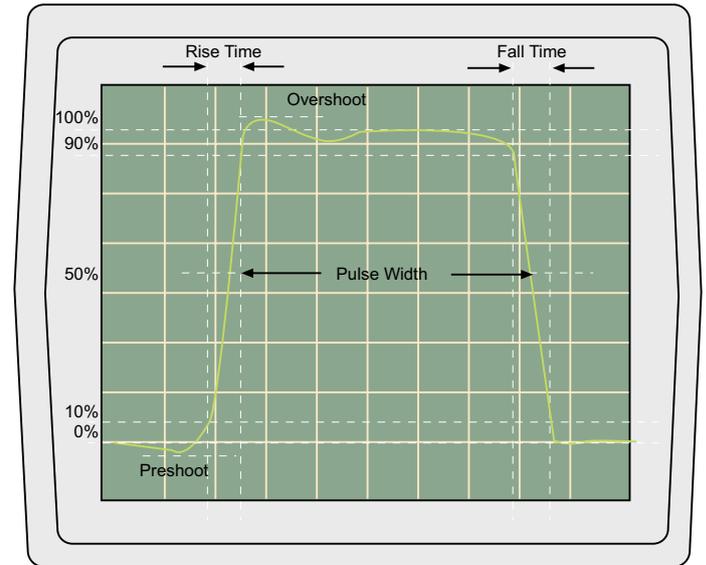
On digital oscilloscopes, there are normally facilities to carry out calculations on the waveforms and save the information and or waveform to a file or download it to a computer.

VOLTAGE MEASUREMENT

As the sensitivity of the vertical channel is known, the voltage level can be measured. Remember to take account of whether a x1 or x10 probe is used.

TIME MEASUREMENT

Similarly as the time base is known the time interval between two points can be determined by measuring the divisions on the horizontal scale.



PULSE WIDTH

This is normally taken as the time the signal is above 50% and of the peak value of the waveform.

RISE TIME

This is normally taken as the time between the 10% and 90% of the peak value of the waveform.

FALL TIME

This is normally taken as the time between the 90% and 10% of the peak value of the waveform.

ACCESSORIES

PASSIVE VOLTAGE PROBES

There are several sub-types within the passive voltage probe category. The most important sub-types are:

- 1X voltage probes
- 10X voltage probes (most common)
- 100X voltage probes
- High voltage probes

1X, 10X, and 100X refer to attenuation ratios; a 1X probe does not attenuate the signal, a 10X probe reduces signal amplitudes by 10X, and a 100X probe reduces signal amplitudes by 100X.

A typical 1X probe will load your circuit with 1 Megohm and 100pf or more. This much capacitance can affect the operation of some circuits.

A typical 10X probe will load your circuit with 10 Megohms and 10-15pf. Most circuits operate correctly with this kind of loading.

For some sensitive circuits, a 100X probe is best. A typical 100X probe will load your circuit with 100 Megohms and only a couple of pF.

Some probes are switchable between 1X and 10X attenuation. This can be useful, but will have a lower bandwidth in the 1X position.

10X is usually the best compromise of circuit loading and signal attenuation.

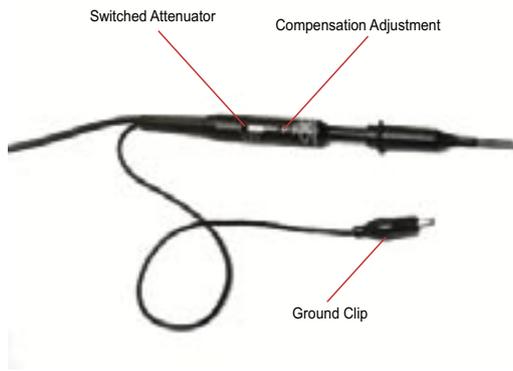


Figure 1

In choosing the probe to use for a particular measurement, you must consider such factors as circuit loading, signal amplitude, and scope sensitivity.

The 1-to-1 probe offers no attenuation of the signal under test and is, therefore, useful for measuring low-level signals.

Scope probes have a maximum bandwidth, just like scope input circuits. Choose a probe that is about the same bandwidth (or perhaps a little faster) than your scope. If you are measuring slow signals, you can use a low bandwidth probe on a fast scope without introducing problems.

Bandwidth is determined by the frequency where the amplitude drops to less than 3 dB (70.7%).

Ground Clip

Measuring a signal requires two connections: the probe tip connection and a ground connection. Probes come with an alligator-clip attachment for grounding the probe to the circuit under test. In practice, you clip the grounding clip to a known ground in the circuit.

Input Capacitance

Flat frequency response makes square waves look square. Extra gain at high frequencies makes the front corners of square waves look spiked or peaked. Not enough gain at high frequencies makes the front corners of square waves look rounded.

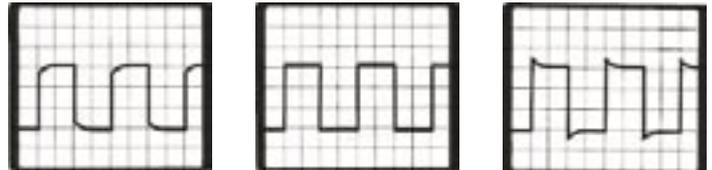
Because it attenuates the signal, the 10X attenuator probe makes it difficult to look at signals less than 10 millivolts. The 1X probe is similar to the 10X attenuator probe but lacks the attenuation circuitry. Use the 10X attenuator probe as your standard probe, but keep the 1X probe handy for measuring weak signals.

Many oscilloscopes can detect whether you are using a 1X or 10X probe and adjust their screen readouts accordingly. However with some oscilloscopes, you must set the type of probe you are using or read from the proper 1X or 10X marking on the volts/div control.

Compensating the Probe

Before using a passive probe, you need to compensate it - to balance its electrical properties to a particular oscilloscope. You should get into the habit of compensating the probe every time you set up your oscilloscope. A poorly adjusted probe can make your measurements less accurate. Figure 2 shows what happens to measured waveforms when using a probe not properly compensated.

Figure 2



- Connect the probe tip to the scope calibrator. Most scopes provide a 1KHz square wave calibrator output.
- Switch the channel input coupling to DC.
- Turn on the scope and set the Volts/Div. switch to provide about four divisions of display.
- Set the sweep rate to 1m Sec./Div.
- Use the alignment trimmer tool to turn compensation adjustment until the tops and bottoms of the square wave are flat.

Current Probe

Either AC or DC types are available. These convert current to voltage as the oscilloscope is a voltage measuring device.