Oscilloscopes are used to make measurements of voltage and time. They are voltmeters that can measure rapidly changing voltages and show how the voltage varies with time. They do this by "drawing" a graph on the screen. The vertical scale on this graph is in volts and the horizontal scale is in units of time.

We have already discussed some of the principles of operation of an oscilloscope in Chapter 35. The main part of an oscilloscope is the cathode ray tube. This is a glass tube that has had all the air removed from it. The tube has a flat fluorescent screen at one end. Inside the tube at the other end is the electron gun and other components that control the focus and the brightness of the line drawn on the screen by the electron beam. The beam is deflected using two pairs of plates to create horizontal and vertical electric fields.

The controls of a typical oscilloscope are shown in Figure 36.2.

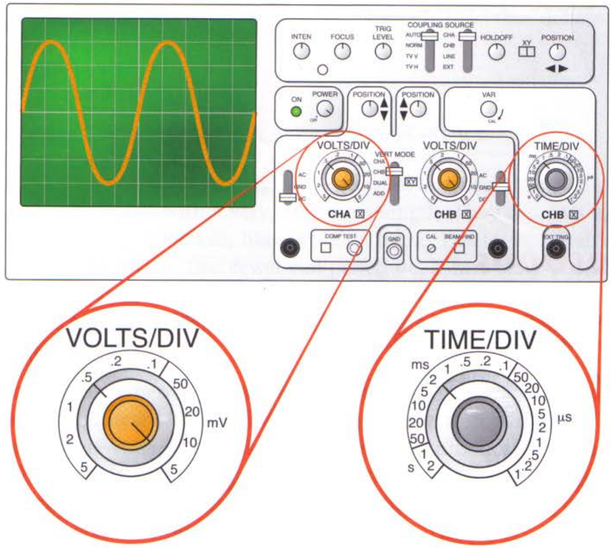

Figure 36.2 *An oscilloscope with all its controls.*

The time scale

The electron beam is produced by the electron gun and sweeps across the screen horizontally. (This is done by an internal circuit, called the **timebase**. The timebase changes the voltage across the horizontal deflecting plates. This makes the electron beam move across the screen horizontally.) The time taken for the beam to travel across one of the divisions on the screen can be controlled. Figure 36.2 shows the control that sets the horizontal time scale. It is marked in time/division (time/div). Notice that some sections of the scale around this control are in seconds per division (s/div), others in milliseconds per division (ms/div) and some in microseconds per division (μs/div).

This setting tells you the horizontal time scale of the graph that the oscilloscope draws on the screen. In Figure 36.2, the timebase is set to 2 ms/div so each horizontal division on the screen represents a time of 2 ms.

The voltage scale

The varying voltage signal that you want to see drawn on the oscilloscope screen is connected to the **Y input**. The signal is amplified and then connected to the vertical deflecting plates. As the voltage changes, the electron beam will be deflected up and down the screen. Figure 36.2 shows the Y-gain control of the amplifier. This control sets the vertical voltage scale of the oscilloscope screen. It is marked out in volts per division (volts/div or V/div) and millivolts per division (mV/div). This setting tells you the vertical voltage scale of the oscilloscope graph – in Figure 36.2 it is 0.5 V/div.

Setting up an oscilloscope for use

First turn the oscilloscope on. Usually this will result in some kind of trace (line) appearing on the screen. If not, look for the horizontal and vertical position controls. These controls will have arrows like those shown in Figure 36.3a, indicating either horizontal or vertical motion. When you have found them, set them to the middle of their range of movement.

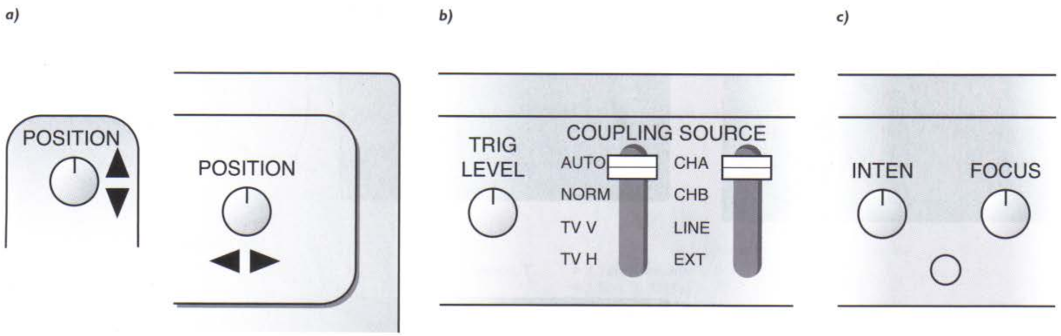

Figure 36.3 a) *The vertical and horizontal position controls – each should be set to the middle of its range of movement,* b) *trigger control – set to "auto" and the channel in use, if the oscilloscope is dual trace,* c) *brightness and focus controls.*

As you do this, you may notice the trace moving into view on the screen. If the trace is still not visible, make sure that the trigger control (Figure 36.3b) is set to "auto". One further reason that the trace may not be visible is if the brightness (sometimes called intensity) control has been turned down. A standard setting for the brightness control is around two thirds of its maximum range. If you have done these things, you should now have a horizontal line on the screen. If the line appears blurred you can focus it with the focus control, shown in Figure 36.3c. (The line will also appear blurred if the brightness is set too high.)

Using the oscilloscope

Suppose you want to find out the frequency and amplitude of a signal produced by a signal generator. First you must connect the signal generator up to the oscilloscope, as shown in Figure 36.4.

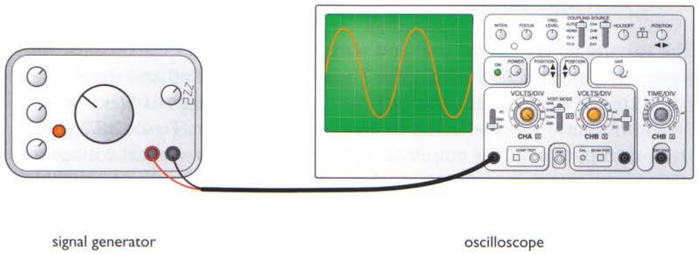

Figure 36.4 *Connecting the CRO to a signal generator.*

Next you must adjust the time and voltage scales on the oscilloscope so you can see the voltage waveform clearly. Figure 36.5a shows what you should see with suitable settings of the controls. Figures 36.5b and 36.5c show incorrect settings and how to correct them.

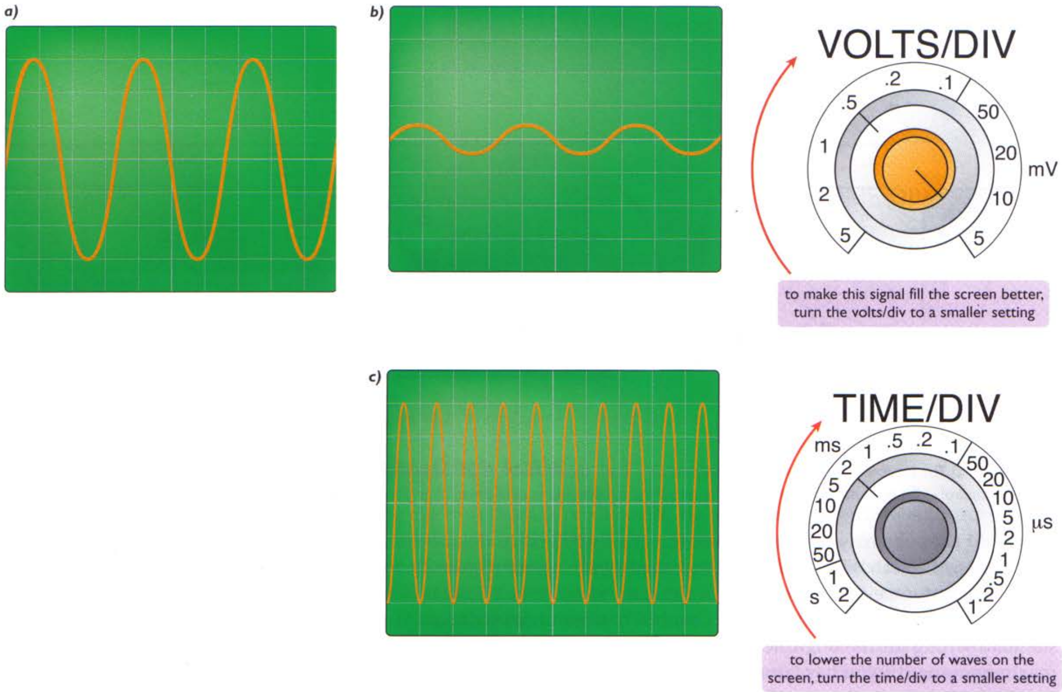

Figure 36.5 *Adjusting the time and voltage scales on the oscilloscope so that you can see the voltage waveform clearly.*

Measuring the amplitude

The **amplitude** of a wave is its height from the mid position (see page 142). Measure the height of the voltage signal against the scale marked on the CRO screen. Multiply the height in screen divisions by the setting on the volts/div (V/div) control to find the amplitude (Figure 36.6).

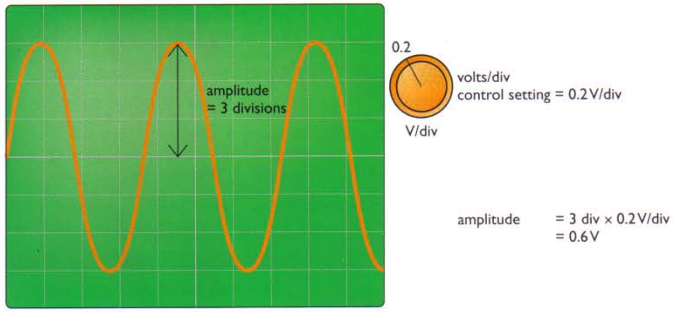

Figure 36.6 *Measuring the amplitude of a signal.*

Measuring the frequency

The **frequency** of a wave is the number of cycles of the wave there are in one second (see page 142). To measure the frequency of a voltage signal, you first need to measure the **period**, T, of the signal. To do this, count the number of divisions across the screen that a whole cycle of the wave takes up. Multiply the number of divisions by the setting on the time/div control (Figure 36.7).

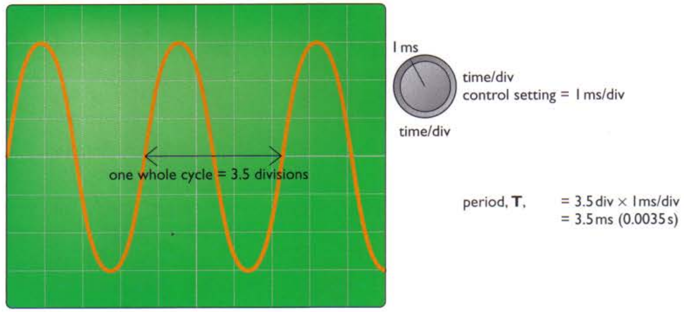

Figure 36.7 *Finding the period of a waveform.*

The frequency, f, of a waveform is given by:

$$\text{frequency, } f = \frac{1}{\text{period, } T}$$

where f is measured in hertz (Hz) if T is measured in seconds (s).

So the frequency of the waveform shown in Figure 36.7 is:

$$\text{frequency, } f = \frac{1}{0.0035\ \text{s}}$$
$$= 286\ \text{Hz}$$