

Overview

In this unit your students should:

- understand how a raster scan can display an image with rows of pixels
- learn how calculate the video bit rate of a monochrome monitor
- see how square wave signals can be built up from sine wave signals
- relate the bandwidth of a video signal to its bit rate

This should not require more than 4 hours of class time.

Hour	Suggested Activity
1	<p>You could introduce the topic by issuing each student with a hand lens and inviting them to study the screen of a computer monitor. Discuss the idea of a raster scan before launching them into the Refresh rate practical.</p> <p>Ask them to study 5.1 before the next session.</p>
2	<p>Get your students to start the Raster scan practical. It is important that they perform the specified tests at the end of each step before continuing on to the next one.</p> <p>Step 5 is largely extension work. Students will be able to finish it in a later session.</p> <p>Ask students to answer the Monochrome exercises before the next session.</p>
3	<p>Discuss their answers to the Monochrome exercises.</p> <p>Get them to do the Square wave components practical. You could end the session by using an oscilloscope with a spectrum analyser to show the spectrum of sine, triangle and square waves.</p> <p>Ask students to answer the three questions on page 88 of the textbook before the next session.</p>
4	<p>Students who need more time to complete the questions from the textbook should use this session accordingly.</p> <p>The rest could usefully work through step 5 of the Raster scan practical.</p> <p>Ask them to study 5.2 before the next session.</p>

Model Answers

- 1 (a) A frame displays the whole picture, using lines of pixels. Each pixel is a dot which can emit light. The refresh rate is the number of times the frame of pixels is updated in each second.
- (b) Pixels per line \times lines = pixels per frame, so pixels per line = $786\,432 / 768 = 1024$.
- (c) The cable bit rate = pixels per frame \times refresh rate = $786\,432 \times 60 = 47 \times 10^6 \text{ s}^{-1}$.
The worst-case signal has pixels alternating high and low along a line (10101010...) giving a square wave with $47 \times 10^6 / 2 = 24 \times 10^6$ cycles per second. At least a fundamental sine wave of frequency 24 MHz must get through the cable for this worst-case signal to be displayed on the screen.
- 2 (a) The moment-by-moment voltage of the video signal carries information about the required state of the pixel being accessed at that instant by the raster scan.
- (b) The line sync signal pulses each time the raster scan reaches the end of a line of pixels. The frame sync signal pulses each time the scan reaches the end of the last line of a frame.
- (c) Immediately after a frame sync pulse, the video signal is applied to the top left-hand pixel of the screen. The video signal is then applied to the pixels in that line, one after the other from left to right until the line sync pulse arrives. The operation is then repeated for the next line down. Once the video signal has been applied to the last line of the frame, a frame sync pulse starts the whole process again.
- (d) Human eyes can detect the flicker of light which is switched on and off at a frequency of less than 25 Hz. By refreshing the screen faster than this, you don't notice each frame being replaced with another.
- 3 (a) Each frame is refreshed in 24 ms. It takes $120 \mu\text{s}$ to refresh each line of pixels, so pixels per frame = $24 \times 10^{-3} / 120 \times 10^{-6} = 200$.
- (b) The frame is refreshed every 24 ms, so refresh rate = $1 / 24 \times 10^{-3} = 420 \text{ Hz}$
- (c) The worst-case signal of 10101010... has a frequency of 1.3 MHz.
The bit rate is therefore $2 \times 1.3 \times 10^6 = 2.6 \times 10^6 \text{ s}^{-1}$.
One line is refreshed in $120 \times 10^{-6} \text{ s}$, during which time the video signal applies $2.6 \times 10^6 \times 120 \times 10^{-6} = 312$ bits, one for each pixel in the line