Overview

In this unit your students should:

- how clusters of pixels can be used to display images in colour
- understand the operation of a digital-to-analogue converter based on a summing amplifier
- learn how compression techniques can be used reduce the bandwidth of a video signal

This should not require more than 5 hours of class time.

Hour	Suggested Activity
1	Get your students to answer question 1 of the **Colour** exercises. As they finish, get them to do the **Monitor signals** practical. Steps 9 to 11 are extension work. Ask them to answer questions 1 and 2 on pages 88 and 89 of the textbook for the next session.
2	Launch your students straight into the **DAC design** practical. Steps 5, 6 and 7 are extension work. Ask them to answer questions 2, 3 and 4 of the **Colour** exercises before the next session.
3	Discuss their answers to questions 2, 3 and 4 of the **Colour** exercises. Get them to work through the remaining questions of the **Colour** exercises before resuming work on the **DAC design** practical. Ask them to answer questions 3 and 4 on page 89 of the textbook for the next session.
4	Students who have completed their answers to all the questions from the textbook should tackle the **Digital waveforms** practical. It is mostly extension work. The rest should concentrate on the questions from the textbook.
5	Start the session by taking a photograph of the group with a digital camera. Then launch them into the **Image compression** practical, using the image you have just taken. Ask them to revise **Video Displays** for a formal test next session.

Model Answers

1 (a) The line sync signal informs the monior to start refreshing a new line. The frame sync informs the monitor to start refreshing a new frame.

(b) The red, green and blue video signals control the intensities of the separate coloured pixels in each cluster.

(c) The sync signals can be digital because they use short pulses to trigger events, and a pulse is a digital signal (high or low). The intensity of a pixel, which is controlled by its video signal, has one of a number of different levels, so is an analogue signal. Converting that signal into a series of bits to represent each level results in a signal which requires an impossibly large bandwidth.

2 (a) One pixel for each basic colour (red, green and blue) detected by the human eye.

(b) Four levels for a single pixel requires a two-bit word ($2^2 = 4$), so needs $3 \times 2 = 6$ bits to control all three pixels in a cluster.

(c) Bits per line = $6 \times 640 = 3\,840$, so bits per frame = $350 \times 3\,840 = 1\,344\,000$.
Bit rate = bits per frame × refresh rate = $1\,344\,000 \times 60 = 80\,640\,000\ \text{s}^{-1}$.

(d) Compression reduces the number of bits required to refresh a frame by removing information without making any perceptible difference to the image seen on the screen.

(e) The advantage of compression is that it reduces the bit rate required to form the image, reducing the bandwidth required for transmitting it in real time and reducing the amount of memory required to store the image. The disadvantage is that it omits finer details of the image, reducing its quality.

3 (a) The DAC has $2^4 = 16$ levels over a range of 3.00 V, giving it a resolution of 0.20 V.

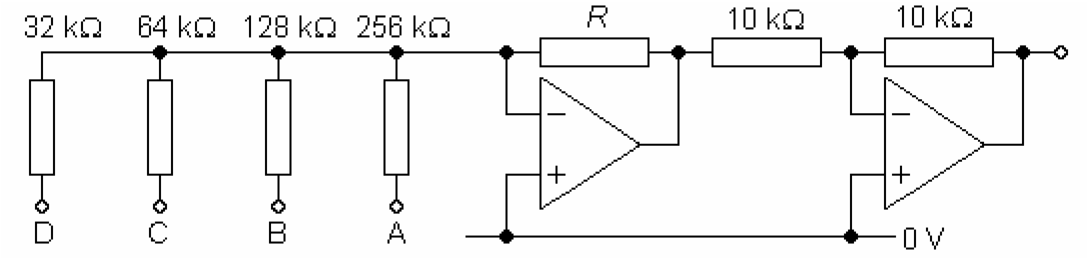
(b) For DCBA = 0001: $-\dfrac{V_{out}}{R} = \dfrac{V_A}{R_A}$ so $-\dfrac{-0.2}{R} = \dfrac{+5}{256 \times 10^3}$

and $R = \dfrac{0.2 \times 256 \times 10^3}{5} = 10.24 \times 10^3$ Ω or 10.24 kΩ.

Check for DCBA = 111:

$$-\frac{V_{out}}{10.24 \times 10^3} = \frac{5}{32 \times 10^3} + \frac{5}{64 \times 10^3} + \frac{5}{128 \times 10^3} + \frac{5}{256 \times 10^3} = 293 \times 10^{-6}$$

so $-V_{out} = 293 \times 10^{-6} \times 10.24 \times 10^3 = -3.00$ V as required



4 (a) Bit rate for each video signal = $1024 \times 768 \times 50 = 39\ 321\ 600\ s^{-1}$
Worst-case signal is 1010101..., looking like a square wave with a frequency of $39.3 \times 10^6 / 2 = 19.7$ MHz. Bandwidth needs to be at least 20 MHz to allow the fundamental sine wave component at 19.7 MHz through to the monitor.

(b) Any noise or interference picked up between the computer and monitor can be removed by restoring the signal with a logic gate. It also allows compression to be used, and makes it easy to store the image in a memory.

(c) Each pixel has eight different intensity levels, so requires three bits of information as $2^3 = 8$. So bit rate per video signal = $39\ 321\ 600 \times 3 = 118 \times 10^6\ s^{-1}$. To accommodate the worst-case signal of 101010..., the bandwidth needs to be at least $118 \times 10^6 / 2 =$ 59 MHz.

(d) Analogue format requires a much lower bandwidth, resulting in cheaper circuitry and cables.