Chapter 9
Peripheral Devices

9.1 A hard drive has eight surfaces, with 521 tracks per surface and a constant 64 sectors per track. Sector size is 1K bytes. The average seek time is 8 ms, the track-to-track access time is 1.5 ms, and the drive runs at 3,600 rpm. Successive tracks in a cylinder can be read without head movement.

a. What is the drive capacity?

b. What is the average access time for the drive?

c. Estimate the time required to transfer a 5 MB file.

d. What is the burst transfer rate? (§9.1)

Solution: a. Capacity = $8 \times 521 \times 64 \times 1$ K = 266.752 MB

b. Rotational latency = Rotation time/2 = $\frac{60}{3600 \times 2} = 8.3$ ms

Average access time = Seek time + Rotational latency = $8 + 8.3 = 16.3$ ms

c. Assume this file is stored in successive sectors and tracks, starting at sector #0, track #0 of cylinder #*i*. A 5 MB file will need 1,000 blocks and will occupy from cylinder #*i*, track #0, sector #0, to, cylinder #(*i*+9), track #6, sector #7. We also assume the size of disk buffer is unlimited.

The disk will need 8 ms, which is the seek time, to find the cylinder #*i*, 8.3 ms to find sector #0, and $8 \times (60 / 3600)$ seconds to read all 8 tracks' data of this cylinder. Then, the time needed for the head to move to next adjoining track will be only 1.5 ms, which is the track-to-track access time. Assume a rotational latency before each new track.
Access time =

$$8 + 9 \times (8.3 + 8 \times 16.6 + 1.5) + 8.3 + 6 \times 16.6 + \frac{8}{64} \times 16.6 = 1406.9 \text{ ms}$$

d. Burst rate = $\frac{\text{revs}}{\text{sec}} \times \frac{\text{sectors}}{\text{rev}} \times \frac{\text{bytes}}{\text{sector}} = \frac{3600}{60} \times 64 \times 1 \text{ K} = 3.84 \text{ MB/s}$

9.3 An advanced hard disk uses zone-bit recording. Its innermost track is at an inside diameter of 0.75". There are 128 sectors on the innermost track, each of which holds 512 bytes. Track-to-track spacing is 0.1 mm, and the disk rotates at 7,200 rpm. The designer has decided to create a new zone each time an additional, complete sector can be added. What will be the inside diameter of the second zone? (§9.1)

Solution: Assume the innermost track is called track #0. Suppose track #n is the first track of the second zone. Then,

$$\pi \times (n \times \text{Track spacing} + \text{Inside diameter}) - \pi \times \text{Inside diameter} = \frac{\pi \times \text{Inside diameter}}{\#\text{ sectors of innermost track}}.$$

Thus we have $n = \left\lceil \dfrac{\text{Inside diameter}}{\#\text{ sectors of innermost track} \times \text{Track spacing}} \right\rceil$.

That is, $n = \left\lceil \dfrac{0.75 \times 25.4}{128 \times 0.1} \right\rceil = 2$ (1 inch = 25.4 mm). Thus, the inside diameter of second zone $= 0.75 \times 25.4 + 2 \times 0.1 = 19.07$ mm.

9.5 A VDT has a 60 Hz refresh rate, and displays 132×64 dot matrix characters. Each character is on a 14×20 dot matrix, including intercharacter spacing.

a. What must the size of the display memory be?

b. What is the dot clock frequency? (§9.2)

Solution: a. Display memory is $132 \times 64 = 8448$ bytes. (It is a VDT. Data are stored as characters.)

b. Dot clock frequency $= 132 \times 64 \times 14 \times 20 \times 60 = 141.9264$ MHz.

9.7 An advanced color monitor has a $1{,}250 \times 1{,}250$ pixel display, at 72 dpi. It can display 24 bits per pixel. The refresh rate is 60 Hz.

a. What is the active display area, $h \times v$?

b. What is the rate at which the 24-bit wide memory must be accessed in bytes/second?

c. What is the monitor frequency? (§9.2)

Solution: a. $h \times v = \dfrac{1250}{72} \times \dfrac{1250}{72} = 301.4 \text{ in}^2$

b. Access rate $= 1250 \times 1250 \times \dfrac{24}{8} \times 60 = 281.25$ MB/s

c. Vertical scan frequency = 60 Hz. Horizontal scan frequency $= 1250 \times 60 = 75$ KHz

9.9 A 3" × 4", 24-bit color image with a resolution of 300 dpi is to be printed on a 300 dpi color laser printer. How many bytes will be transmitted to the printer, and how long will it take to transmit them over a 300 bps serial line, assuming a 10-bit serial frame? (See Figure 10.6 for the definition of a serial frame.) (§9.3)

Solution: $3 \times 4\ \text{in}^2 \times 300\ \text{dots/in}^2 \times 24\ \text{bits / dot} \times \frac{1\ \text{byte}}{8\ \text{bits}} = 3.24 \times 10^6\ \text{bytes}$

Transmission time =

$$3.24 \times 10^6\ \text{bytes} \times \frac{10\ \text{bits}}{\text{byte}} \times \frac{1\ \text{second}}{300\ \text{bits}} = 108,000\ \text{s} = 30\ \text{min}$$

9.11 A laboratory instrument requires 1 mV accuracy on a 10 V, full-scale measurement, and must be able to acquire 10 samples per second. Specify the DAC that will meet these requirements. (§9.5)

Solution: The ADC will need to resolve to .001/10 or 1 part in 10,000. This means at least 14 bits of precision. If a successive approximation converter is used, it will take 14 clocks to provide a sample. To provide at least 10 samples per second, the ADC will need to be clocked at 140 Hz.