backlighting can be used if the displays have to be read in the dark. One noticeable disadvantage is that the display is clearly visible only when you look straight at it. Visibility is much reduced when viewing at an angle.

Transmissive displays (TMCs) are used with a white backlight, and the liquid crystal dots will transmit whatever colour is selected from the whole spectrum of white light. These displays are ideal for use in low-lighting conditions.

Reflective displays (RFCs) are used illuminated by white light, and will reflect whatever colour is selected from each liquid crystal dot. No backlight is needed, so that power requirements are very low, but they can be used only in bright lighting conditions, and the perceived colours will alter if the illumination is not white light.

Transflective displays (TFCs) combine both TMC and RFC principles, and use both a backlight and the ambient light to provide a display that can be read equally easily in the dark or in sunlight. The user can save power by having the backlight off in high ambient light.

Both LED and LCD displays can be made in a variety of patterns, of which the seven-segment display is the most common. Another useful type of display is the dot-matrix, using a set of dots for each character. This is used with LCD and with LED displays. Figure 15.7 shows a typical 5 × 7 matrix display and the schematic arrangement of LEDs. Any character of the alphabet or number digit (alpha-numeric character) can be displayed, and using larger matrices such as 8 × 15 allows for international characters to be displayed. Other formats for displays are starburst patterns, a variant of segmented display pattern that allows for alpha-numeric characters, and bar graphs. Bar-graph displays are very commonly used as audio level meters in hi-fi equipment.

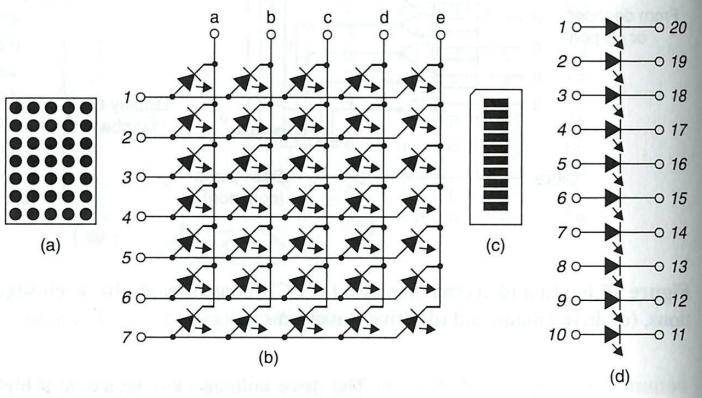

Figure 15.7 Typical displays: (a) matrix display, (b) typical LED connections, (c) bar graph, and (d) LED connections

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All forms of display require driver circuits that will accept normal digital logic level inputs and provide outputs that are suitable for operating the display segments. For number or alphabetical displays, combined decoder–drivers are used to implement the decoding logic required; illustrated in (Figure 15.5). The decoder–driver and display is often combined so that no wiring is needed other than power supplies and inputs.

Multiple-choice revision questions

15.1 Which switch debouncing method is most appropriate for the type of switch called SPCO (single-pole change-over)?
(a) RC input Schmitt
(b) microprocessor software delay
(c) RS flip-flop
(d) NAND gate.

15.2 When a standard seven-segment LED display is driven, each segment draws about 5 mA from the supply. What is the difference between the maximum and minimum current drawn for the numbers from 0 to 9?
(a) 5 mA
(b) 25 mA
(c) 20 mA
(d) 50 mA.

15.3 What is the effect of a low-value d.c. drive on an LCD?
(a) will damage the display
(b) all the segments are displayed simultaneously
(c) light is emitted
(d) will cause the display to explode.

15.4 What is the main advantage of a dot-matrix display?
(a) low current requirement
(b) can display any pattern
(c) requires fewer resistors
(d) costs less than a seven-segment type.

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Figure 19.5 Components marked with this symbol in the service schematic are safety critical and should be replaced with identical types, as directed by the service manual

pattern generators, through digital oscilloscopes with the facilities for the display of both time- and frequency-based signals, to signal strength meters suitable for selecting the required transmissions and accurately aligning aerial systems.

Most consumer devices are mains powered, and when work is carried out on such equipment components the demanding safety requirements of mains connection must be met.

Particular care must be taken over **critical components**, usually marked out on a service sheet (Figure 19.5). These must be replaced with factory-approved components because a replacement may otherwise present a safety hazard. The repairer would be held liable for damage caused as the result (of a fire, for example) caused because a critical component had been replaced by an unapproved substitute.

Video recording

The recording of analogue video signals on magnetic tape follows the same basic principles as analogue audio recording. However, the very wide bandwidth of the video signal requires that the tape pass the record head at a much greater speed than is possible with a conventional analogue tape machine. To achieve the required speed of tape past the head, two or more heads are mounted on a spinning drum which is mounted to scan the head across the tape at a shallow angle. This allows the tape to move relatively slowly past the spinning drum. The helical scan system has been under development since the late 1950s, with the VHS system introduced in the early 1980s and largely unchanged today. Additional features include multiple heads to provide better still-frame playback and long play/record performance, and there have been massive reductions in unit cost owing to improved manufacturing and electronic integration. The general arrangement of helical scan **VCR** tape path is shown in Figure 19.6.

When the cassette is inserted in the machine, the first operation is threading; this is feeding the tape through the tape path around the drum so that it can be played or recorded. To achieve this, the front cover of the cassette is lifted as the cassette drops into position. The unthreaded position of the loading arms means that the slant poles, guide rollers, tension pole and capstan spindle are behind the tape; these are all mounted on movable loading arms. The threading operation uses the loading arms to move the slant poles, guide rollers, etc., to their operating position (Figure 19.5), carrying the tape around the circumference of the head drum and past the audio, control and erase heads. The slant poles now perform their main function, which is to guide the tape on to the drum at the correct angle for it to be scanned by the passing of the heads.

The analogue audio signal is recorded on a narrow strip along one edge of the tape, while field sync. pulses are recorded on the opposite edge. The heads and tape travel in the same direction to minimize frictional losses and to extend the mechanical lifetime.

The luminance signal is frequency modulated on to a carrier of about 4.3 MHz, which swings through the range of about 3.8–4.8 MHz between

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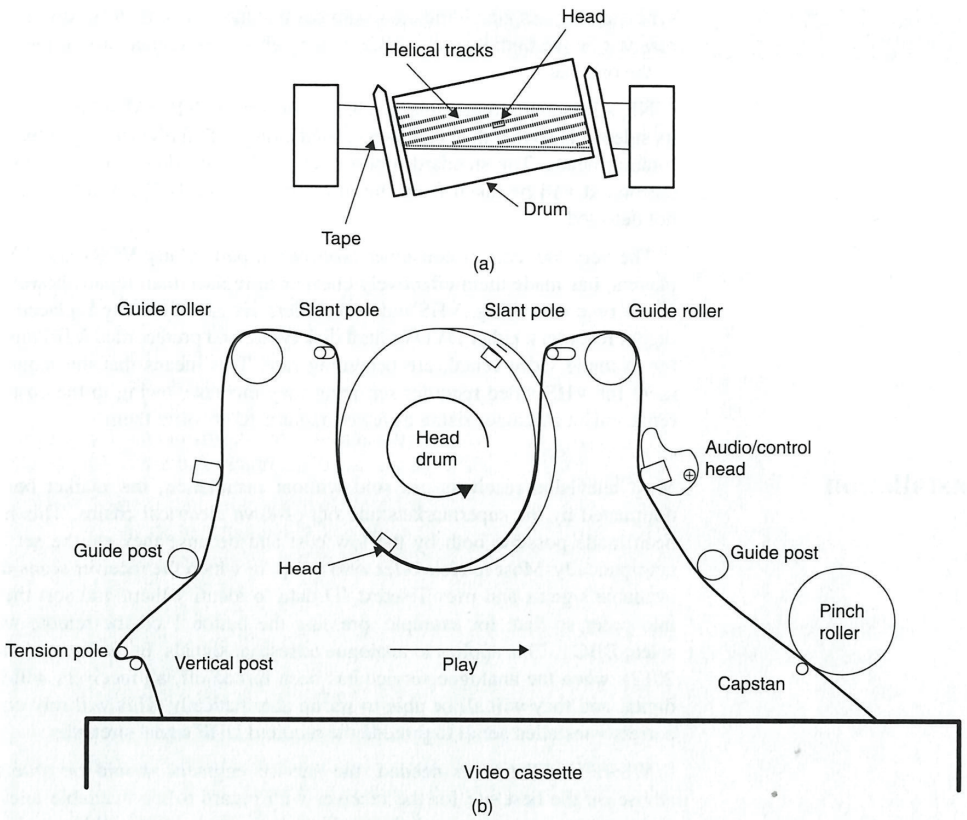

Figure 19.6 Tape transport of typical helical scan video recorder: (a) tracks on tape, and (b) tape path

sync. pulse tip and peak white. Because this FM signal is of constant amplitude, it can be recorded on tape without needing a higher frequency bias signal as used in audio recording, since it is not affected by the amplitude distortion introduced by the magnetic hysteresis of the tape. The FM luminance signal is used as the recording bias signal for the chrominance component, which is down-converted to a **colour under frequency** of about 625 kHz and added to the luminance signal for recording. The replay follows the inverse process; the tape speed is locked to the required vertical sync. rate, the luminance and chroma signals are recovered along with the sound signal. These are typically available via the SCART connector and on some new machines and most older ones remodulated onto a UHF carrier for input to the television receiver aerial socket.

To ensure synchronism, the tape capstan drive motor is locked to the vertical sync. pulses, while the head drum rotation is locked to the horizontal

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the easiest method is to mount the old drive in an external drive casing, plug into the USB or Firewire port of the computer, and use Windows to copy data files.

Optical (CD/DVD) drives

The optical drive allows the use of CD or DVDs that carry computer codes, and these are extensively used to contain programs and other information (such as multimedia text, pictures, audio or video). Older CD-ROM drives are read-only, but a later generation of drives permits both reading and writing. The conventional CD-ROM will hold about 700 Mbytes of data. The later development, the DVD read/write drive, is almost universally fitted to modern computers, and can read or write CD or DVDs, either the R (write once only) or the RW (write, read, delete, rewrite) type.

The optical system makes use of optical recording, using a beam of light from a miniature semiconductor laser. Such a beam is of low power, a matter of milliwatts, but the focus of the beam can be to a very small point, about 0.6 μm in diameter; for comparison, a human hair is around 50 μm in diameter. The beam can be used to form pits in a flat surface, using a depth which is also very small, in the order of 0.1 μm. If no beam strikes the disk, then no pit is formed, so that this system can digitally code pulses into the form of pit or no-pit. These pits on the master disk are converted to pits of the same scale on the copies. The pits/dimples are of such a small size that the tracks of the CD can be very close; about 60 CD tracks take up the same width as one vinyl LP track, and the tracks on a DVD are closer still. The pits are arranged into a spiral track starting near the hub of the disk and ending near the edge. Digital signals of 8 bits are converted into 14-bit signals to allow for error-reduction methods to be used, and also to avoid long runs of the same digit (0 or 1) occurring.

Reading a set of pits on a disk also makes use of a semiconductor laser, but of much lower power since it need not vaporize the material. The reading beam will be reflected from the disk where no pit exists, but scattered where there is a pit. The rotational speed of the disk is controlled so that the rate of reading pits is constant. This means that the disk spins more quickly at the start of the track than it does at the end. By using a lens system that allows the light to travel in both directions to and from the disk surface it is possible to focus a reflected beam on to a photodiode, and pick up a signal when the beam is reflected from the disk, with no signal when the beam falls on to a pit. The output from this diode is the digital signal that will be amplified and then processed eventually into an audio signal. Only light from a laser source can fulfil the requirements of being perfectly monochromatic (one single frequency) and coherent (no breaks in the wave-train) so as to permit focusing to such a fine spot.

> Focusing and track location are automatic. The returned reading beam is split and the side beams detected so that servo circuits can locate the track and focus on it. This mechanism must not be disturbed unless you have had training in servicing optical drives.

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The optical reader drive uses the laser beam reading system that was originally developed for music CDs, but the speed of rotation of the disk is usually much higher. When you buy a CD-ROM drive, you will see this speed quoted as a multiple of the normal speed of the music CD, such as 20×, 32×, and so on. This allows the disks to be read at higher speeds, so that information can be read from a CD almost as quickly as it could from old hard drives. The normal rotational speed of DVDs is much higher, so that higher speeds are more usually in the range of 2× to 10×. At the time of writing, optical drives that are being fitted to computers will take either the older single-layer writable DVD (4.7 GB) or the later double-layer type (8.5 GB). Further developments of the DVD system such as Blu-ray and HDVD can store much larger amounts of data per disk.

Note that the double-layer disks cannot (at the time of writing) be written with a continuous file of 8.5 GB; you need to record one layer to its limit and then write a separate file on the other layer.

The form of optical drives is fairly well standardized now, as a slim 5¼ inch casing. The front panel holds a drive-on light, a volume control and a headphone jack. This allows the use of the drive for playing ordinary audio CDs. The output audio signal is typically 0.6 V r.m.s. at 1 kHz.

When a button on the front panel is pressed, a tray slides out so that a disk can be placed in the tray, and pressing the button again will cause the tray to slide back in. The drive motor then spins the disk (taking a second or so to build up to full speed), and from then on the disk can be accessed, usually as drive D:. Windows allows you to specify Autostart, so that when a CD or DVD is inserted it will run its program(s) automatically.

There are three connectors at the rear of the CD-ROM drive, the power connector feeding +5 V and +12 V DC, an audio output connector for amplifiers, and the data interface. The audio interface typically uses a four-pin connector. The data interface uses a 40-pin insulation displacement connector (IDC) type.

The CD-ROM drive contains a low-power laser, but because the beam can focus to such a small point, it can cause damage to your eyes. No attempt should be made to use a CD reader with the casing removed, and if focusing problems are encountered, the unit should be returned to the manufacturer.

Figure 23.7 shows a simplified block diagram for a typical optical drive unit. The control signals set the speed of the drive motor, which is not constant; it runs faster when the inner tracks are being read and slower for the outer tracks, keeping the data speed constant. The beam position drives select the track and maintain focus, and the optical head reads the signals reflected from the track. These signals are then converted into conventional digital data in the interface.

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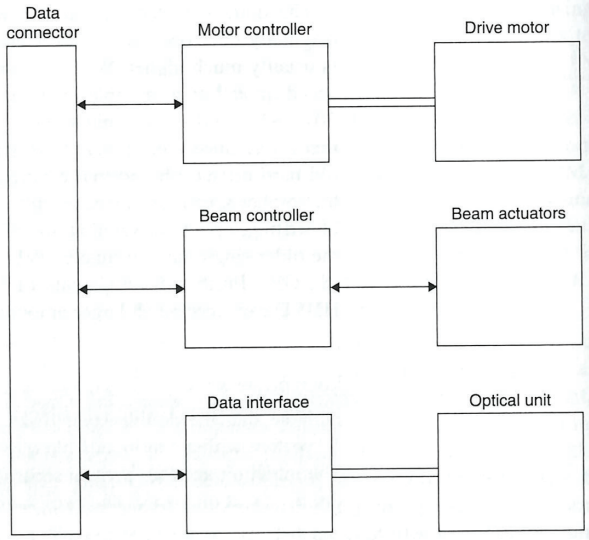

Figure 23.7 Block diagram, simplified, for a CD-ROM drive

Multiple-choice revision questions

23.1 A floppy is being written to and an error message appears. Which of the following **cannot** be the cause of the problem?
(a) the disk has had its write-protection set
(b) there is no floppy-disk driver software
(c) the disk is not formatted
(d) the disk is full.

23.2 Any make of hard drive intended for a PC can be used as a replacement for a faulty unit. This is because:
(a) no driver software is needed
(b) the controller on the motherboard can be used with any drive
(c) the controller is built into the drive
(d) all hard drives are of identical design.

23.3 A hard drive can have a large data capacity because it:
(a) is physically larger than a floppy
(b) runs at a faster speed than a floppy
(c) does not have to be inserted and removed
(d) uses many platters of magnetic material.

23.4 Which of these is NOT an advantage of a hard drive as compared to a floppy?
(a) it has a much greater data capacity
(b) it is faster in use
(c) it does not need to be formatted
(d) it can hold the Windows software.

23.5 A hard drive sometimes does not start until it is tapped. This is because:
(a) there is excessive friction on the drive motor spindle
(b) there is too much software on the drive
(c) the drive is not formatted
(d) air has entered the drive casing.

23.6 A CD-ROM is inserted but does not start sending data to the computer. This is because:
(a) the drive is not formatted
(b) the drive is faulty
(c) Autostart has not been activated in Windows
(d) the CD-ROM is faulty.

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