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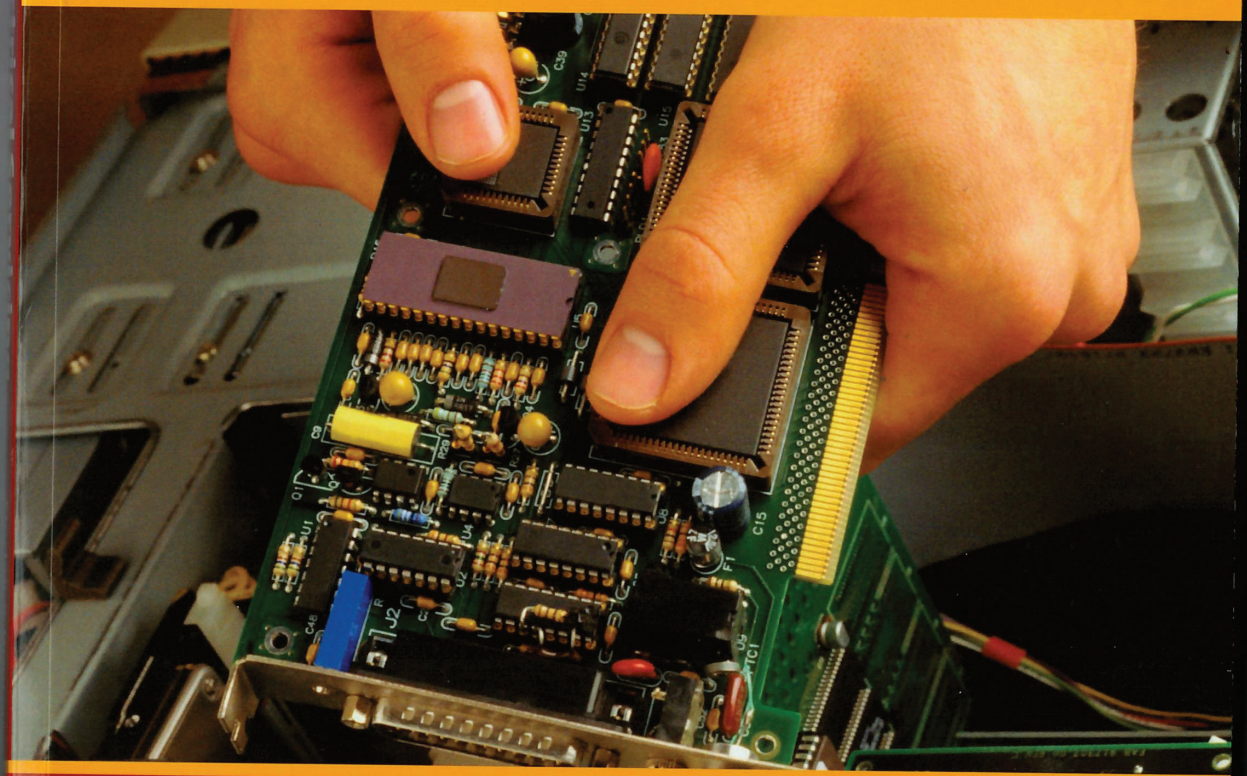
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Electronic and Electrical Servicing

Consumer and Commercial Electronics



Ian Sinclair & John Dunton

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Electronic and Electrical Servicing

Consumer and commercial electronics

Second Edition

Ian Sinclair

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telegraphs. The power that is required is in the low milliwatt level, and even a few milliwatts can produce considerable pressure amplitude at the eardrum, often more than is safe for your hearing when the earphone is a snug fit into the ear.

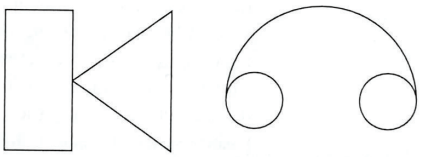


Figure 10.7 Symbols for (a) loudspeaker, and (b) headphones

The methods that are used for loudspeakers and for headphones are essentially the same as are used for microphones, because the action is (unusually) reversible.

Loudspeakers for domestic equipment are often **full-range** units, meaning that one loudspeaker transducer deals with the whole range of audio signals. This is not really satisfactory because it is very difficult to make a loudspeaker unit that will cope with such a range, and the few full-range units that can be classed as hi-fi loudspeakers are usually of exotic (and expensive) design, such as the Quad electrostatic units. Small full-range speakers of acceptable quality are widely used in radios, cassette recorders and compact disc players at the low end of the price range.

For anything that can be (loosely) classed as hi-fi, separate loudspeakers are used for the audio range, with one (woofer) dealing with the lower frequencies and another (tweeter) dealing with the high frequencies. The two units are normally enclosed in one cabinet, but on speaker sets such as those intended for home cinema equipment, the tweeters are arranged around the room and a single subwoofer (for the frequencies in the range 30–150 Hz) is located centrally. The stereo effect depends almost completely on the higher frequencies, so the positioning of the woofer/subwoofer is not critical. A filter, called a **cross-over unit**, separates the signal into lower and upper frequencies so that the higher frequencies are fed to the tweeters and the lower frequencies to the woofers.

Most loudspeakers use the moving-coil principle (Figure 10.8). The coil is wound on a former at the apex of a stiff diaphragm which is held in flexible supports so that the coil is the intense field of a permanent magnet. A signal current through the coil will then vibrate the diaphragm, producing sound waves at the same frequency and with the same waveshape as the signal. To be really effective, a loudspeaker has to be housed in a cabinet (**enclosure**) whose design assists the loudspeaker to move a large volume of air, acting like a transformer for air waves. Even in a fairly good enclosure, the efficiency of a typical hi-fi loudspeaker is very low, around 1%.

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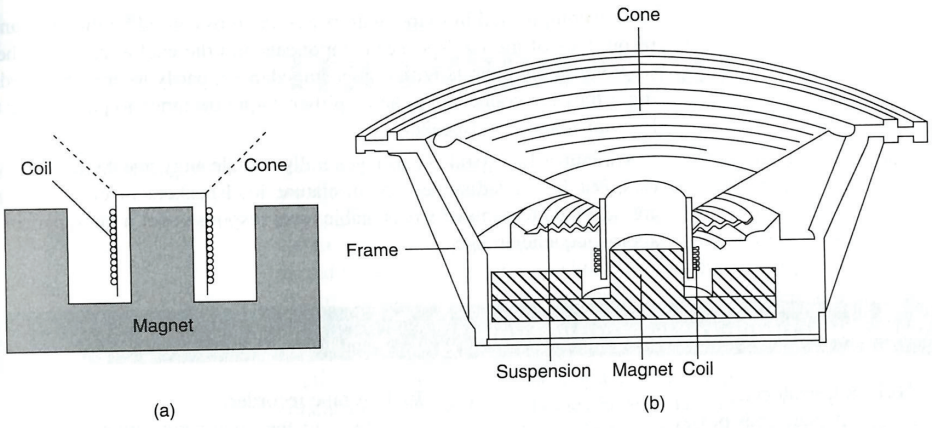


Figure 10.8 Moving-coil loudspeaker: (a) cross-section of coil and magnet, and (b) cutaway view of complete unit

Miniature loudspeakers, typically of diameter 70 mm or less, are used as warning transducers in cars, signal devices on electronic equipment, and in toys. These small units can be used also as microphones, although their efficiency as a microphone is low and the frequency response is uneven. Confusingly, the same term is also used for hi-fi loudspeakers that are noticeably smaller than average.

Headphones

Headphones can be constructed using any of the principles used for loudspeakers, but the most widespread and successful type is the **electrodynamic** (or **orthodynamic**) principle. This uses a diaphragm which has a coil built in, using printed circuit board techniques. The coil can be a simple spiral design, or a more complicated shape (for better linearity), and the advantage of the method is that the driving force is more evenly distributed over the surface of the diaphragm.

The **piezoelectric** principle has also been used for headphones in the form of piezoelectric sheets that can be formed into very flexible diaphragms. A piezoelectric material is one whose dimensions can be changed by applying an electric field, and which will generate an electric field if the material is compressed. Quartz crystals are piezoelectric, and another crystalline material that is extensively used is barium titanate.

Moving-coil headphones have also been manufactured and the quality that can be attained justifies the high prices that are attached to these units.

Subminiature earphones, often referred to as *earbuds*, are designed for use with portable CD or MP3 players, and run at a typical rated power of 3 mW. These use the same dynamic mechanism as larger earphones. The impedance is typically 32 Ω.

Moving-coil loudspeakers and earphones have a nominal value of impedance, typically 4 ohms, but a graph of impedance plotted against frequency

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capacitor had charged via the resistor up to the threshold before the trigger could change state. If the switch contacts bounce, the change in voltage at the input is not rapid, because of the time constant, so the output voltage is unaffected. Buffers and logic gates are obtainable with Schmitt switching characteristics, and microcontrollers often have Schmitt inputs on some pins. Although this can be effective, it is not perfect, and more elaborate methods are often used.

Another method of debouncing switch contacts is to connect the switch to an RS flip-flop. Figure 15.3(a) shows a typical switch debounce circuit. To understand what happens, we need to recall how the RS flip-flop works: the output changes only when one input is at logic 0 and the other is at logic 1. When the inputs are both at logic 1, the output remains unchanged in whatever state it was last set.

When the switch is at position A, the input to the flip-flop is $\overline{R} = 1$, $\overline{S} = 0$, and this gives $Q = 1$ as the output. Now while the switch is being changed over, both inputs will momentarily be at logic 1, but this does not change the output. When the switch contacts are in position B, the inputs to the flip-flop are $\overline{R} = 0$, $\overline{S} = 1$, giving $Q = 0$. If the switch contacts bounce, making $\overline{R} = 1$, $\overline{S} = 1$, the output remains at 0, so that the switch bounce has no effect. This method of debouncing is usually preferred, and is completely effective when properly implemented.

Debouncing for key pads like those used in telephones, calculators and computer keyboards is usually carried out by application-specific integrated circuit (ASIC) keyboard encoders or software run on a microcontroller. The switches will typically be arranged as a matrix, with the controller driving the rows and reading the columns. When a switch is closed, the controller detects that it has been closed and a time delay starts. Changes in the switch setting have no effect until the end of the time interval. This interval can be several tens of milliseconds, since you cannot type quickly enough to operate a key more than once in that time.

Practical 15.1

Connect a switch and resistor so that when the switch is closed the resistor is connected between a 5 V supply and ground. Use a counter or oscilloscope to measure the pulses caused by bouncing. Assemble a debouncing circuit (either Schmitt or RS flip-flop) and verify that the output of the debouncing circuit changes only once for each switching at its input.

Digital outputs

The outputs from digital circuits may be used to control devices such as motors, to switch on loads via a relay or to drive display devices (see Figure 15.4). Displays are the most common output devices that allow us to interact with electronic systems.

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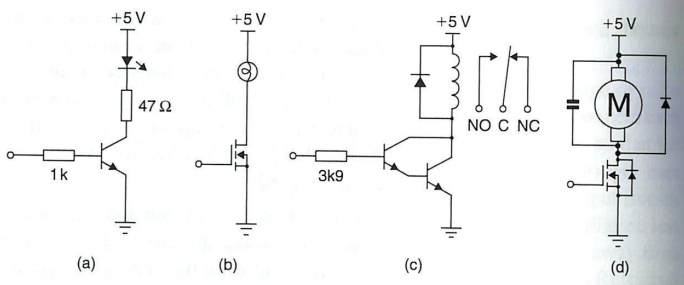
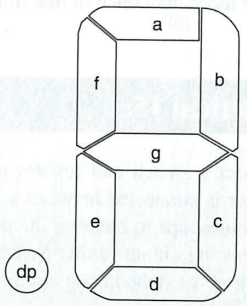


Figure 15.4 Driving loads from digital outputs: (a) transistor driver for high-current LED, (b) FET drive for an indicator bulb, (c) driving a relay with a Darlington pair (note protection diode), and (d) switching a small motor with a MOSFET (note protection diode and electromagnetic compatability (EMC) suppression capacitor)

Light-emitting diodes (LEDs) indicators are diodes that emit light when current passes in the forward direction. Using different semiconductor materials, LEDs can be made to emit light of different colours. Single LEDs can be used to indicate binary numbers by using one LED for each power of two, on for one and off for zero.

Number displays based on segmented displays made with LEDs are commonly used for indicating denary numbers, using integrated circuits (ICs) that convert binary-coded decimal (BCD) to segment drive for a seven-segment type of display (Figure 15.5). As for all LEDs, the amount of current being passed needs to be limited, and this is usually done with a resistor in series with the LED. The brightness of the output is roughly proportional to the current.



Digit	Segments	HEX code
0	a b c d e f	FC
1	b c	60
2	a b d e g	DA
3	a b c d g	F2
4	b c f g	66
5	a c d f g	B6
6	a c d e f g	BE
7	a b c	E0
8	a b c d e f g	FE
9	a b c d f g	F6

Figure 15.5 Seven-segment display

The format of LED indicators can be **common anode** or **common cathode**. For a seven-segment display, for example, each bar can be the cathode of a diode, all of whose anodes are connected, or each bar can be an anode of a diode, with all the cathodes connected. On a common-cathode

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display, the cathode will be earthed and each anode connection driven to a positive voltage so as to illuminate a bar. On a common-anode display, the anode connection will be made to a positive voltage, and the cathode connections earthed by the driver circuits as required.

Liquid crystal displays (LCDs) make use of a quite different principle. They depend on a liquid crystal material that polarizes light when an electrical potential is applied. The display is made by sandwiching this liquid crystal material between transparent metal electrodes deposited on glass substrates (Figure 15.6a), one or both of which are transparent and polarizing. Light passing through it will be polarized by the glass polarizing filter and so the light can be switched on or off by altering the voltage across the liquid crystal, which changes its polarization. The amount of power that is needed is very small, and the brightness of the display is just the brightness of the light that is used. The contrast of the display depends on how well the liquid crystal polarizes; at high and low temperature extremes this may not be as good as at room temperature. This is the principle now widely used for all types of displays, including computer monitors and television displays.

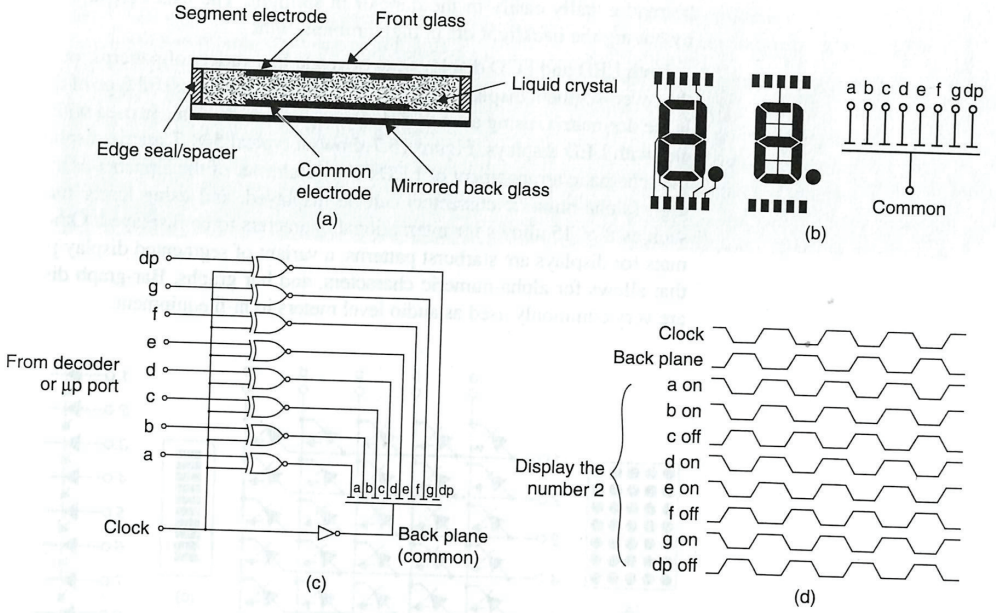


Figure 15.6 Liquid crystal displays: (a) LCD construction, (b) seven-segment display pattern and connections, (c) drive circuit, and (d) drive waveforms

The drive voltage must be a.c. at a high audio frequency, with no trace of d.c., otherwise the liquid crystal may become permanently polarized and the display will lose contrast. LCD displays like those in watches and calculators are reflective, so that they are most visible in bright light, but

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