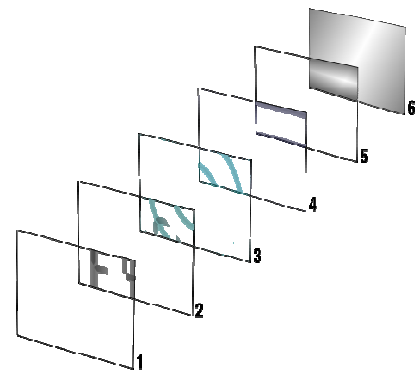


Liquid Crystal Display (LCD)

A **liquid crystal display (LCD)** is a thin, flat panel used for electronically displaying information such as text, images, and moving pictures. Its uses include monitors for computers, televisions, instrument panels, and other devices ranging from aircraft cockpit displays, to every-day consumer devices. It is an electronically-modulated optical device made up of any number of pixels filled with liquid crystals and arrayed in front of a light source (backlight) or reflector to produce images in color or monochrome.



LCD major features are:

- its lightweight construction,
- its portability,
- its ability to be produced in much larger screen sizes.
- Its low electrical power consumption enables it to be used in embedded systems.

Each pixel of an LCD typically consists of a layer of molecules aligned between two transparent electrodes, and two polarizing filters, the axes of transmission of which are (in most of the cases) perpendicular to each other. With no actual liquid crystal between the polarizing filters, light passing through the first filter would be blocked by the second (crossed) polarizer.

LCD Specifications:

Important factors to consider when evaluating an LCD monitor:

- Resolution: The horizontal and vertical screen size expressed in pixels (e.g., 1,024×768).
- Dot pitch: The distance between the centers of two adjacent pixels. The smaller the dot pitch size, the less granularity is present, resulting in a sharper image. Dot pitch may be the same both vertically and horizontally, or different (less common).
- Viewable size: The size of an LCD panel measured on the diagonal (more specifically known as active display area).
- Response time: The minimum time necessary to change a pixel's color or brightness. Response time is also divided into rise and fall time. For LCD monitors, this is measured in btb (black to black) or gtg (gray to gray).
- Input lag - a delay between the moment monitor receives the image over display link and the moment the image is displayed. Input lag is caused by internal

digital processing such as image scaling, noise reduction and details enhancement, as well as advanced techniques like frame interpolation. Input lag can measure as high as 3-4 frames (in excess of 67 ms for a 60p/60i signal). Some monitors and TV sets feature a special "gaming mode" which disables most internal processing and sets the display to its native resolution.

- Refresh rate: The number of times per second in which the monitor draws the data it is being given.
- Matrix type: Active TFT or Passive.
- Viewing angle: (coll., more specifically known as viewing direction).
- Color support: How many types of colors are supported (coll., more specifically known as color gamut).
- Brightness: The amount of light emitted from the display (coll., more specifically known as luminance).
- Contrast ratio: The ratio of the intensity of the brightest bright to the darkest dark.
- Aspect ratio: The ratio of the width to the height (for example, 4:3, 5:4, 16:9 or 16:10).
- Input ports (e.g., DVI, VGA, LVDS, DisplayPort, or even S-Video and HDMI).
- Gamma correction

Example:

An **HD44780 Character LCD** is a standard liquid crystal display (LCD) display device designed for interfacing with embedded systems. These screens come in common configurations of 8x1, which is one row of eight characters, 16x2, and 20x4, among others. The largest commonly manufactured configuration is 40x4 characters, and actually requires two individually addressable HD44780 controllers with expansion chips.



These screens are often found in copiers, fax machines, laser printers, industrial test equipment, networking equipment such as routers and storage devices, etc. These are not the kind of screens one would find in a cell phone, portable television, etc. They are limited to text only, with eight customizable characters. Character LCDs can come with or without backlights, which may be LED, fluorescent, or electroluminescent.

Character LCDs use a standard 14-pin interface. If the screen has a backlight, it will have 16 pins. The pinouts are as follows:

- | | | | |
|----|-----------------------|-----|-------------------------------|
| 1. | Ground | 9. | Bit 2 |
| 2. | VCC (+5V) | 10. | Bit 3 |
| 3. | Contrast adjustment | 11. | Bit 4 |
| 4. | Register Select (R/S) | 12. | Bit 5 |
| 5. | Read/Write (R/W) | 13. | Bit 6 |
| 6. | Clock (Enable) | 14. | Bit 7 |
| 7. | Bit 0 | 15. | Optional backlight power rail |
| 8. | Bit 1 | 16. | Optional backlight power rail |

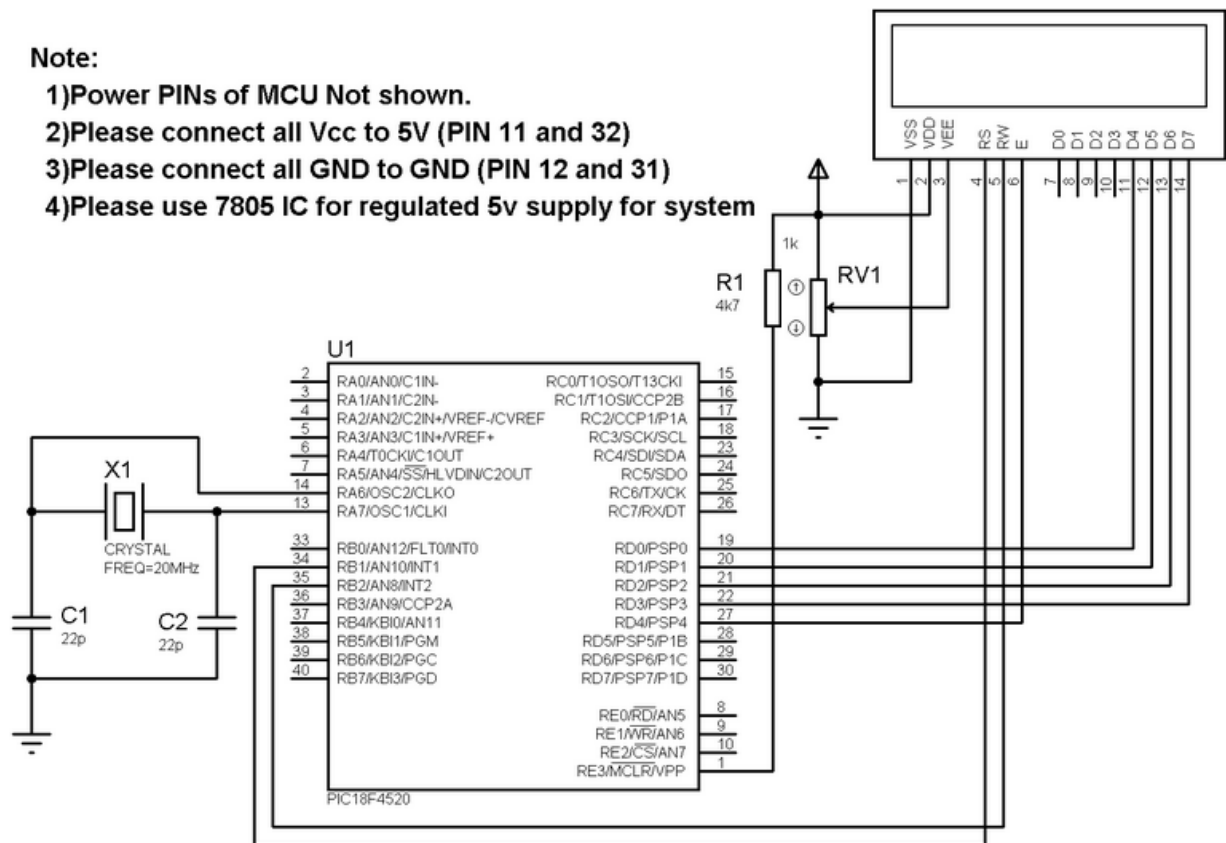
Character LCDs can operate in 4-bit or 8-bit mode. In 4 bit mode, pins 7 through 10 are unused and the entire byte is sent to the screen using pins 11 through 14 by sending 4-bits (nibble) at a time.

The character generator ROM contains 208 characters in a 5x8 dot matrix, and 32 characters in a 5x10 dot matrix.

Example:
LCD Interfacing:

Note:

- 1) Power PINs of MCU Not shown.
- 2) Please connect all Vcc to 5V (PIN 11 and 32)
- 3) Please connect all GND to GND (PIN 12 and 31)
- 4) Please use 7805 IC for regulated 5v supply for system



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