Chapter 6. LCD Display and IR Remote Control Applications

This chapter extends the (software enabled) serial communication of Chapter 5 into the applications of data display and IR remote controller which have many additional applications for projects and other designs.

1. LCD Displaying

Alphanumeric LCD display is very popular for many applications because we can quickly and easily display a result of calculation or measurement, or data for debugging purpose. Of course, as we discussed before, a computer monitor is an excellent tool for the same purpose, but when we build an embedded computing system, much smaller LCD is always useful. There also are graphic LCDs are available.

A LCD is different from a LCD module. A LCD is just a medium to display characters or graphics, it itself also cannot display. A LCD module contains, in addition to the display medium, an interface controller/driver for the LCD. A LCD controller/driver displays alphanumerics and symbols. The most popular LCD controller/driver is the Hitachi 44780 based LCD controller chip. A single HD44780 can display up to one 8-character line or two 8-character lines. It can be configured to drive a dot-matrix liquid crystal display under the control of a 4- or 8-bit microprocessor.

LCD Controller/Driver HD44780
Internally HD44780 has a 80x8-bit display data (DD) RAM for maximum 80 characters, and 9,920-bit character generator(CG) ROM for a total of 240 character fonts (208 character fonts with 5x8 dot size and 32 character fonts with 5x10 dot size), and a 64x8-bit character generator RAM for 8 character fonts (5x8 dot) and 4 character fonts (5x10 dot). It also covers Wide range of instruction functions, "HD44780 Standard Control and Command Code," such as display clear, cursor home, display on/off, cursor on/off, display character blink, cursor shift, and display shift. It contains a reset circuit that initializes the controller/driver after power on.

Display data RAM (DDRAM) stores display data represented in 8-bit character codes. Its extended capacity is 80x8 bits, or 80 characters. The area in display data RAM (DDRAM) that is not used for display can be used as general data RAM. The following table shows the relationships between DDRAM addresses and positions on the LCD.

Position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
First line	00h	01h	02h	03h	04h	05h	06h	07h	08h	09h	0Ah	0Bh	0Ch	0Dh	0Eh	0Fh	10h	11h	12h	13h
Second line	40h	41h	42h	43h	44h	45h	46h	47h	48h	49h	4Ah	4Bh	4Ch	4Dh	4Eh	4Fh	50h	51h	52h	53h
Third line	14h	15h	16h	17h	18h	19h	1Ah	1Bh	1Ch	1Dh	1Eh	1Fh	20h	21h	22h	23h	24h	25h	26h	27h
Fourth Line	54h	55h	56h	57h	58h	59h	5Ah	5Bh	5Ch	5Dh	5Eh	5Fh	60h	61h	62h	63h	64h	65h	66h	67h

In addition to the CGRAM and DDRAM, HD44780 has two 8-bit registers: an instruction register (IR) and a data register (DR). The IR stores instruction codes, such as display clear and cursor shift, and address information for display data RAM (DDRAM) and character generator RAM (CGRAM). The IR can only be written from microprocessor. The DR temporarily stores data to be written into DDRAM or CGRAM and temporarily stores data to be read from DDRAM or CGRAM.

Data written into the DR from the microprocessor is automatically written into DDRAM or CGRAM by an internal operation. The DR is also used for data storage when reading data from DDRAM or CGRAM. When address information is written into the IR, data is read and then stored into the DR from DDRAM or CGRAM by an internal operation. Data transfer to the microprocessor is then completed when the microprocessor reads the DR. After the read, data in DDRAM or CGRAM at the next address is sent to the DR for the next read from the processor. By the register selector (RS) signal, these two registers can be selected. In 16F877 perspective, by controlling the RS line for IR or DR, and sending a DDRAM location for display position and a data for a character to display that position, we can display a character on a desired position.

In addition to the IR and DR, there is Address Counter (AC). The AC assigns addresses to both DDRAM and CGRAM. When an address of an instruction is written into the IR, the address information is sent from the IR to the AC. Selection of either DDRAM or CGRAM is also determined concurrently by the instruction. After writing into (reading from) DDRAM or CGRAM, the AC is automatically incremented by 1 (decremented by 1). The AC contents are then output to DB0 to DB6 when RS = 0 and RW=0.

There are two interfacing method to a microprocessor. The HD44780U can send data in either two 4-bit operations or one 8-bit operation. For 4-bit interface, only four bus lines (DB4 to DB7) are used for transfer: Bus lines DB0 to DB3 are disabled. The data transfer between the HD44780U and the microprocessor is completed only after the 4-bit data has been transferred twice. As for the order of data transfer, the high nibble (DB4 to DB7) are transferred before the low nibble (DB0 toDB3). The busy flag must be checked (one instruction) after the 4-bit data has been transferred twice. Two more 4-bit operations then transfer the busy flag and address counter data. For 8-bit interface, all eight bus lines (DB0 to DB7) are used.

This section will explore the control of a regular LCD module and a serial LCD module. One caution we all have to use is that not all LCD modules are the same: some with different characteristics and pin arrangement, etc. Therefore, before you try to connect a LCD to 16F877, you have to read the data sheet of the module you received or bought. However, once you make yourself familiar with the one presented in this section, on any module of LCD, you can easily change the physical connection and code to adapt to the changing characteristics.

LCD example

A regular LCD module we discuss here is one manufactured by Truly which can display 4 rows, 20 characters per row, with character dot matrix size of 5x8. The exact model number is MTC-C204. So we use 20x4 LCD display with HD44780 controller or equivalent.

The pin arrangement for the LCD module is listed below.

Pin NO.	Symbol	Level	Description
1	V_{SS}	0V	Ground
2	V_{DD}	5.0V	Supply voltage for logic
3	V_O	---	Input voltage for LCD
4	RS	H/L	H : Data, L : Instruction code
5	R/W	H/L	H : Read mode, L : Write mode