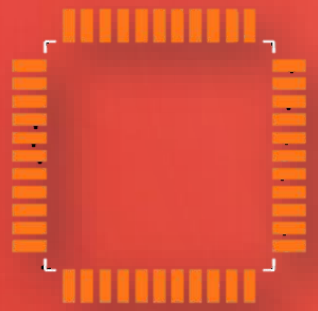
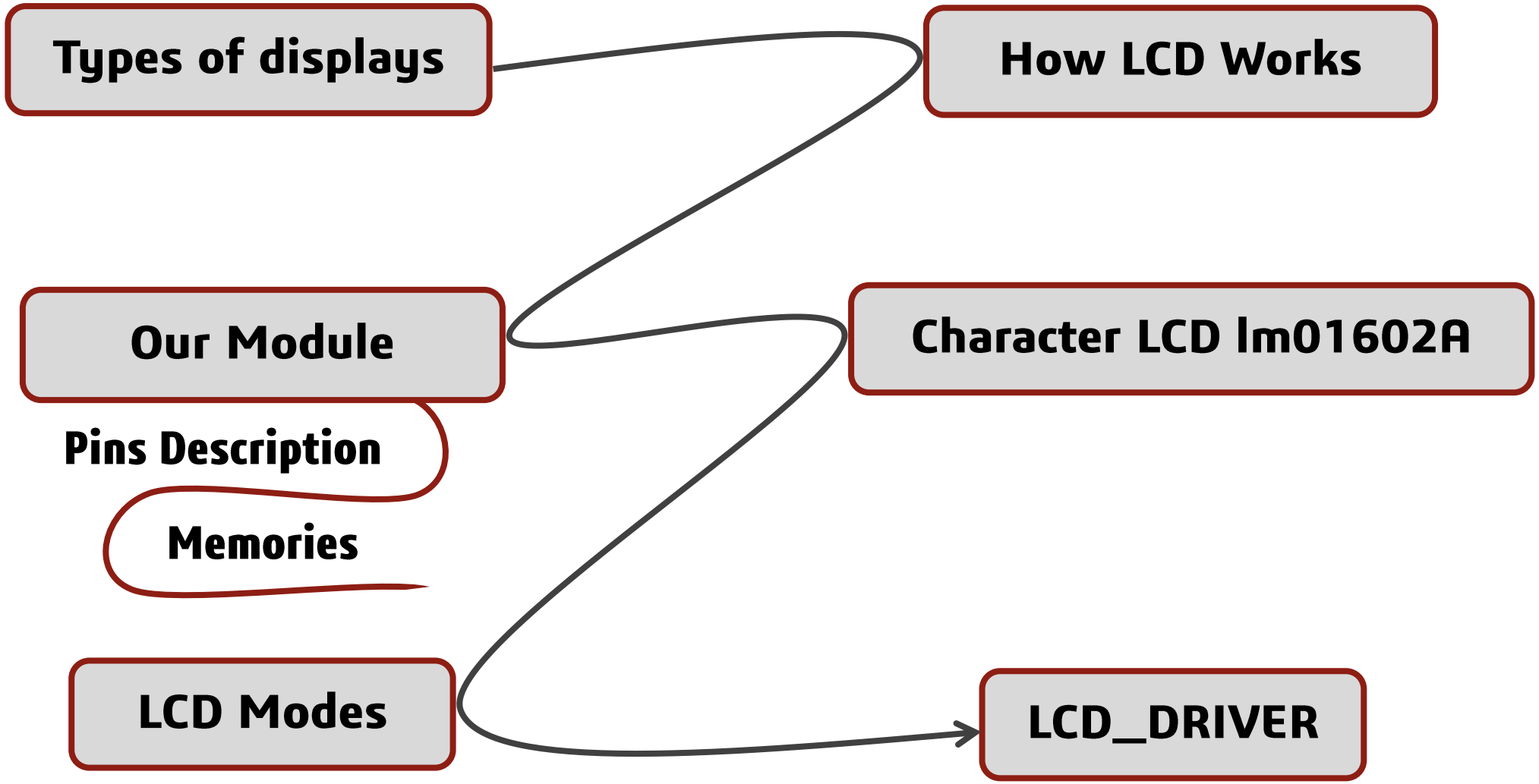


Interfacing

LCD Module

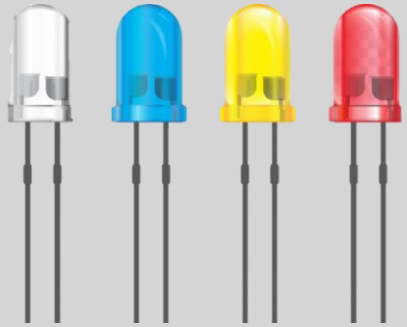
AMIT

Content

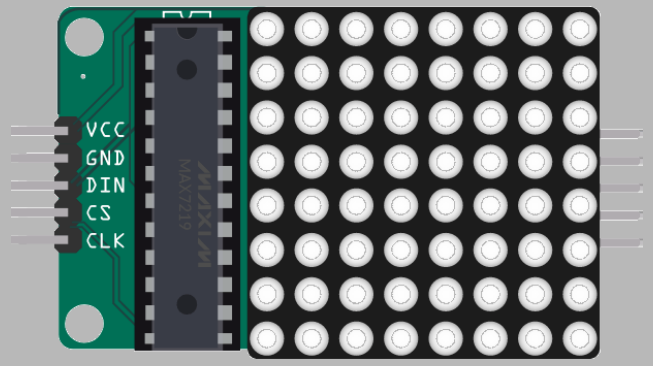

Types of displays
How LCD Works
Our Module
Character LCD lm01602A
Pins Description
Memories
LCD Modes
LCD_DRIVER

Types of displays

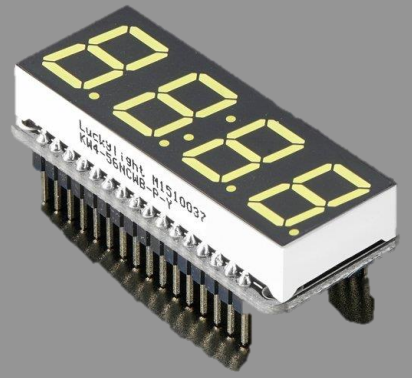
LEDs



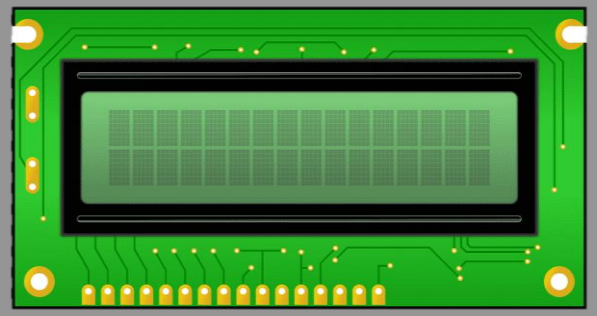
LED Matrix



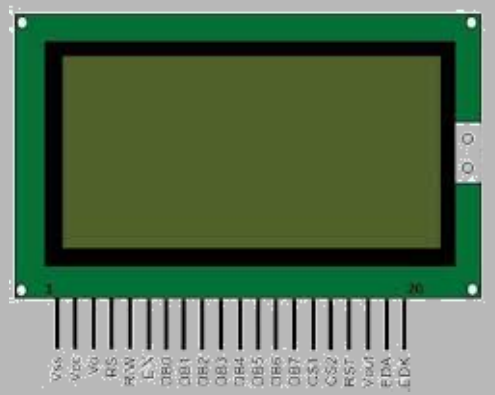
LED Segments



Character Liquid Crystal Display



Graphical Liquid Crystal Display



Thin Film Transistor Liquid Crystal Display (TFT LCD)

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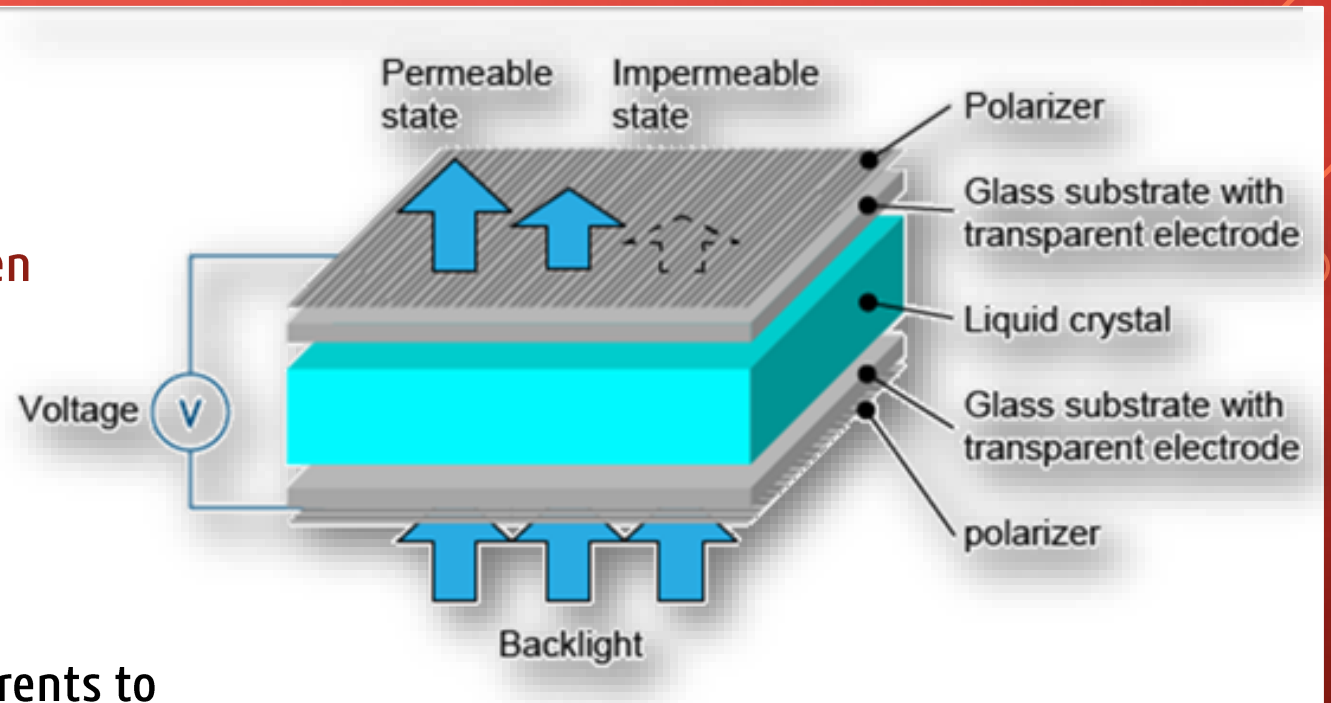
How LCD Works

- LCDs in turn, use **liquid crystals**.
  These crystals are liquid chemicals with molecular structures that align perfectly when subjected to electrical fields
- When they are properly aligned, they allow light to pass through them
- LCDs use this property by using electrical currents to align the crystals, allow varying levels of light to pass through and create the desired images and colors.

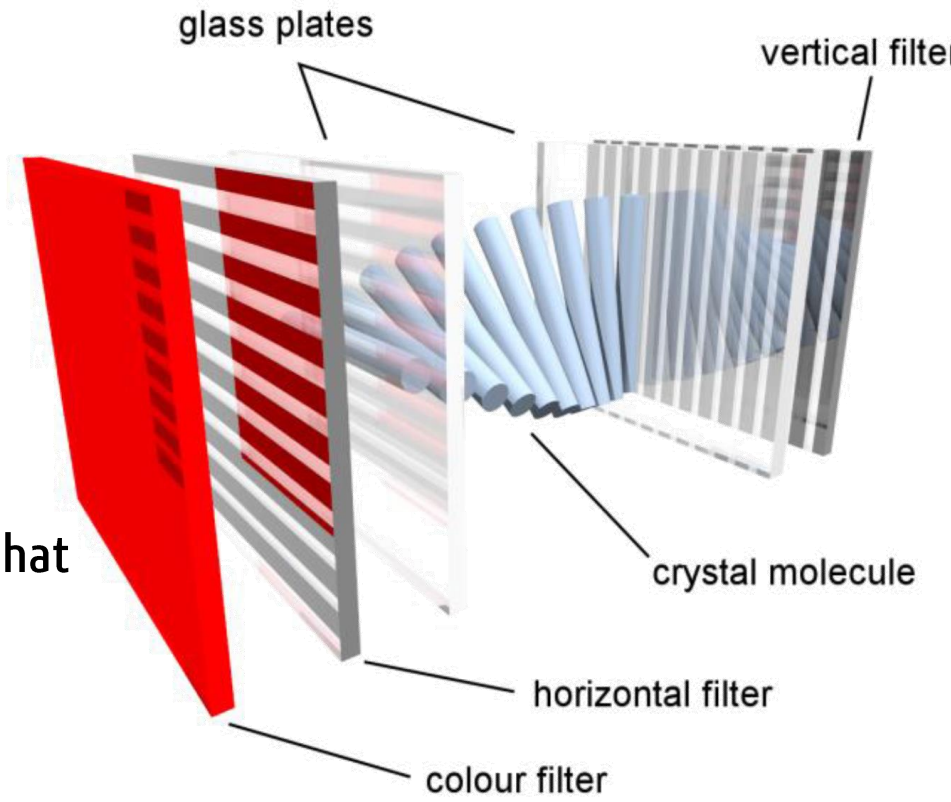


How LCD Works

- To be more technical, the liquid crystals are sandwiched between two pieces of polarized glass (“substrate”).

- The fluorescent light source also known as the backlight originates or radiates light that passes through the first substrate. The polarized light then passes through a layer that contains thousands of liquid crystal blobs arrayed in tiny containers called cells.

- Electric leads around the edge of the LCD create an electric field that causes the crystals’ aligning and allowing varying levels of light to pass through to the second substrate.
The result is what you see on-screen.

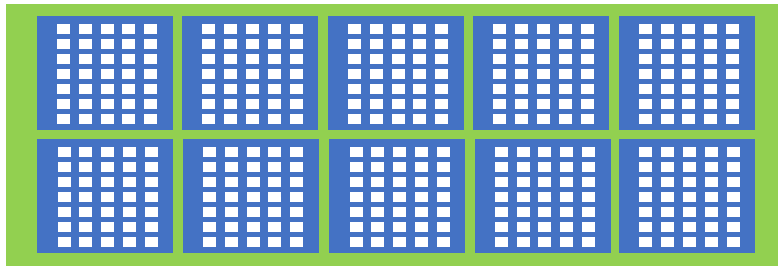


How LCD Works

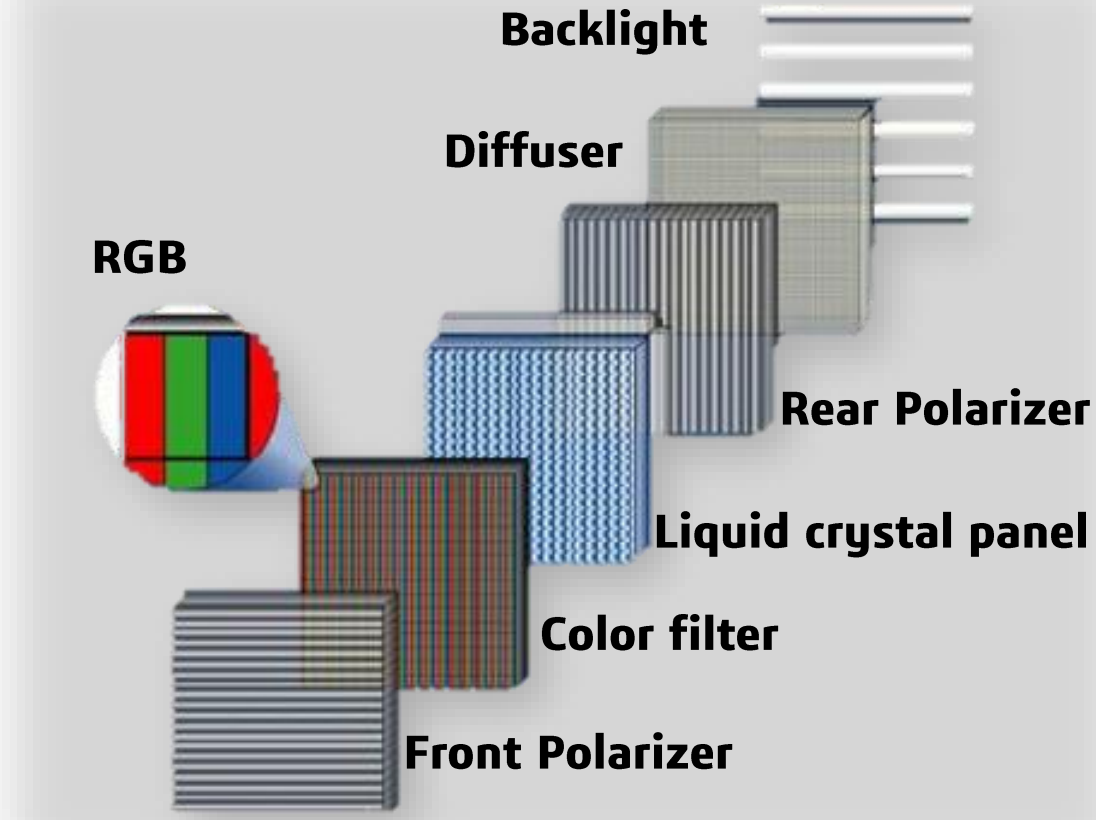
- In a colored LCD panel, each pixel is made up of three liquid crystal cells
  Each of those three cells is fronted by a **RED**, **GREEN** or **BLUE** filter.
  Light passes through the filtered cells and creates the colors what you see on the LCD.

LEDs

Back Light



Pixels



AMIT

Our Module

Character LCDs | **Our Module is Character LCD lm01602A**

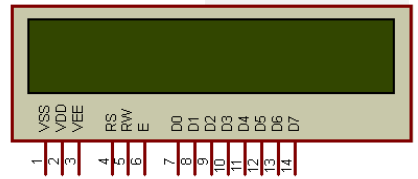
Num.of.Rows x Num.of.Columns

- Most of the LCD Displays available in the market are **16 X 2** (That means, the LCD displays are **capable of displaying 2 lines each having 16 Characters**

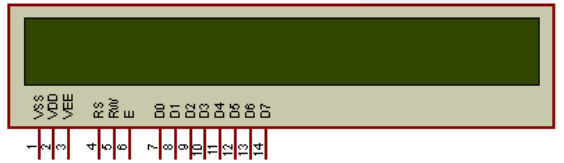
- Thera are a lot of types and sizes of character LCDs

8×1 , 8×2 , 10×2 , 16×1 , 16×2 , 16×4 , 20×2 , 20×4 ,24×2 , 30×2 , 32×2 , 40×2

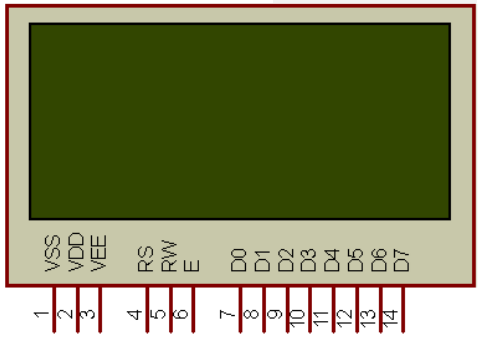
2 x 16



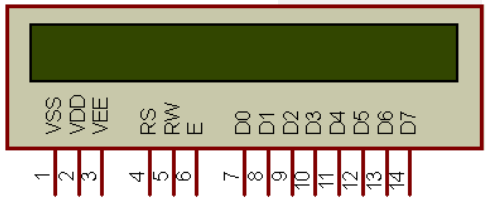
2 x 32



4 x 16



1 x 16



2 x 40

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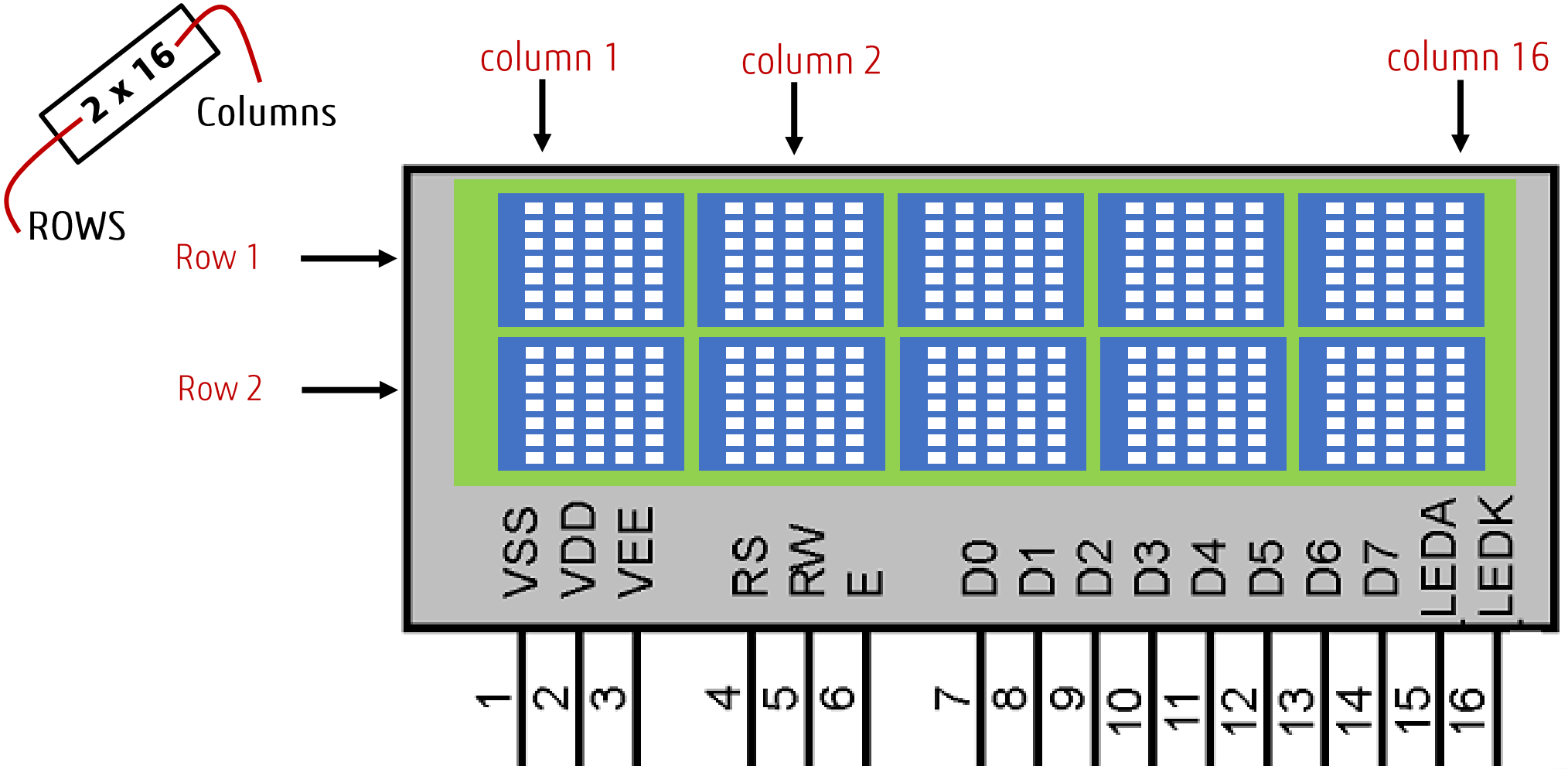
Our Module

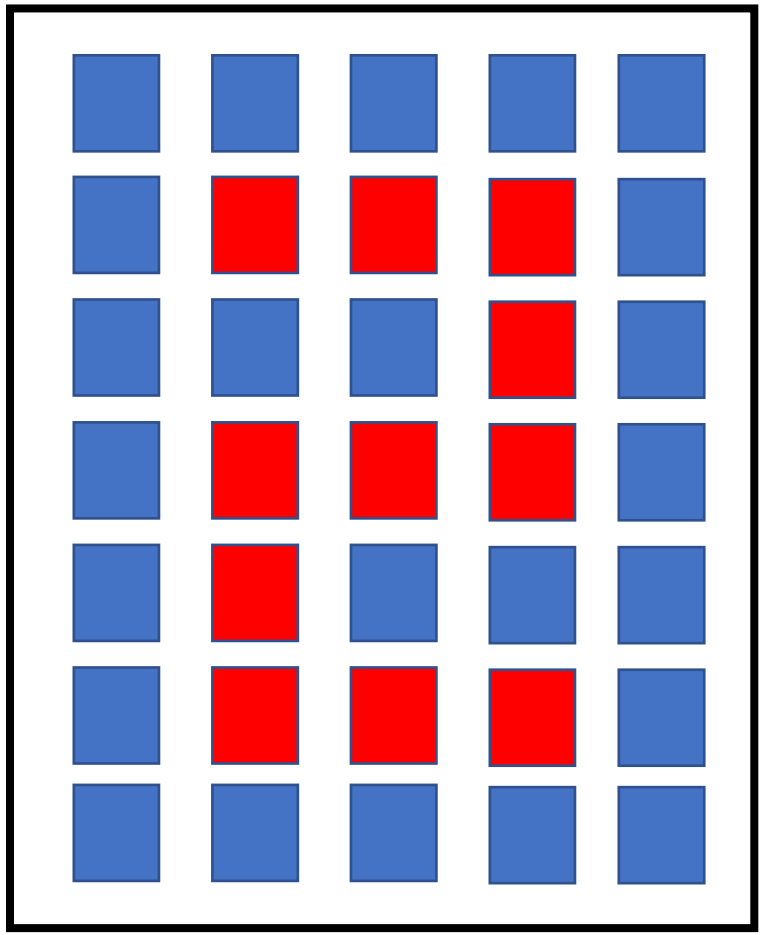
Character LCD lm01602A



Our Module

Every Column

5 x 7 liquid crystals



Applay Voltage

To light the liquid crystals

Controller

Character LCD lm01602A

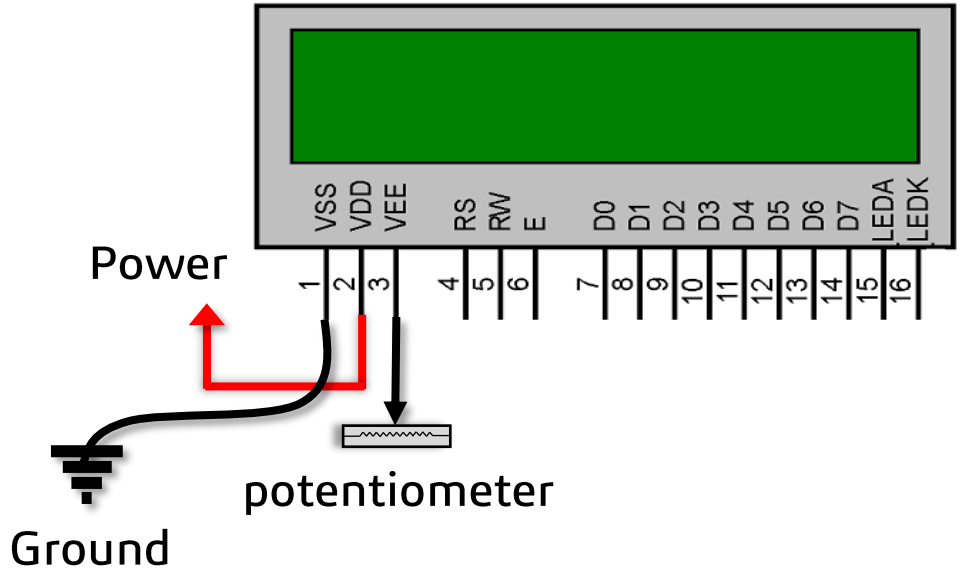
Pins Description

Power Pins

VSS Voltage connected to Source of MOSFET is connected to Ground

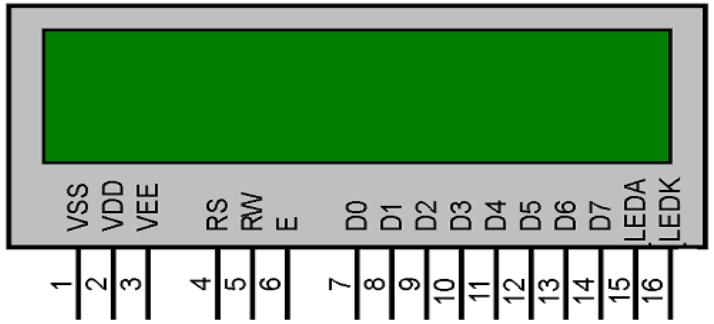
VDD Voltage connected to Drain of MOSFET is connected to High Volt (+5V)

VEE Voltage quantity on this pin controls on the Pixels' Contrast. Max Pixel Contrast is at Low Voltage



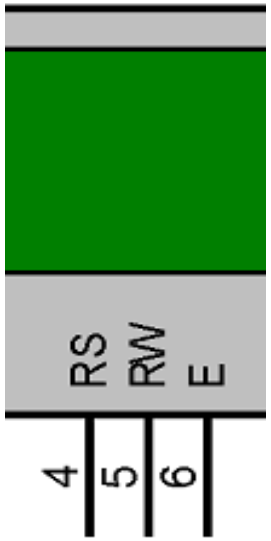
Character LCD lm01602A

Pins Description



Control Pins

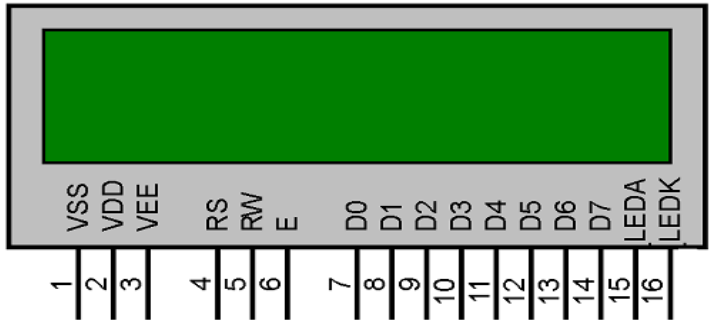
RS — **Register selection** pin, which is used to select the type of data exists on data pins (data to display, **RS** must be pulled up to high **(5V)**or command to LCD, **RS** pin must be pulled down to low **(Ground)**



AMIT

Character LCD lm01602A

Pins Description



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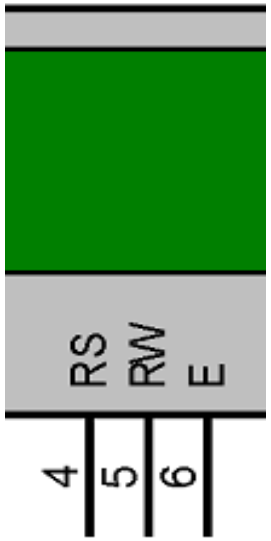
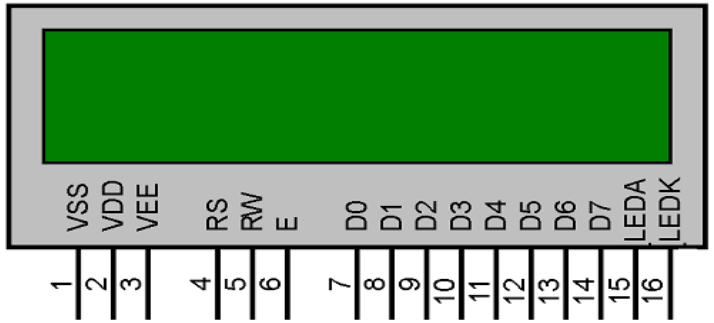
RW — **Read/Write** pin, which determines the kind of operation on LCD. Reading R/W must be pulled up to high **(5V)** and writing R/W must be pulled down to low **(Ground)**



Character LCD lm01602A

Pins Description



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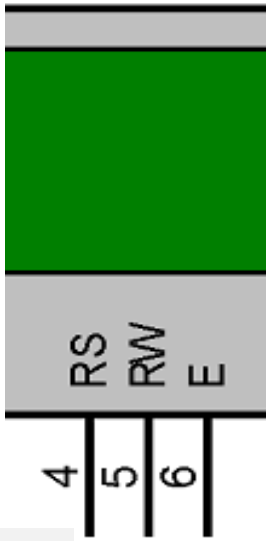

E — Enable pin, which used to enable writing or reading operations on data pins of LCD To enable writing on the LCD, this pin must be triggered by falling edge " latch pulse " (It must be pulled up to high and after very short time (2 MS as example). It must be pulled down to low to generate a falling edge

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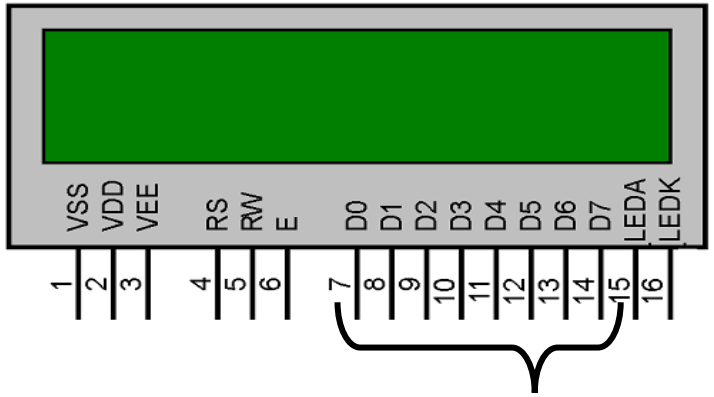
Character LCD lm01602A

Pins Description

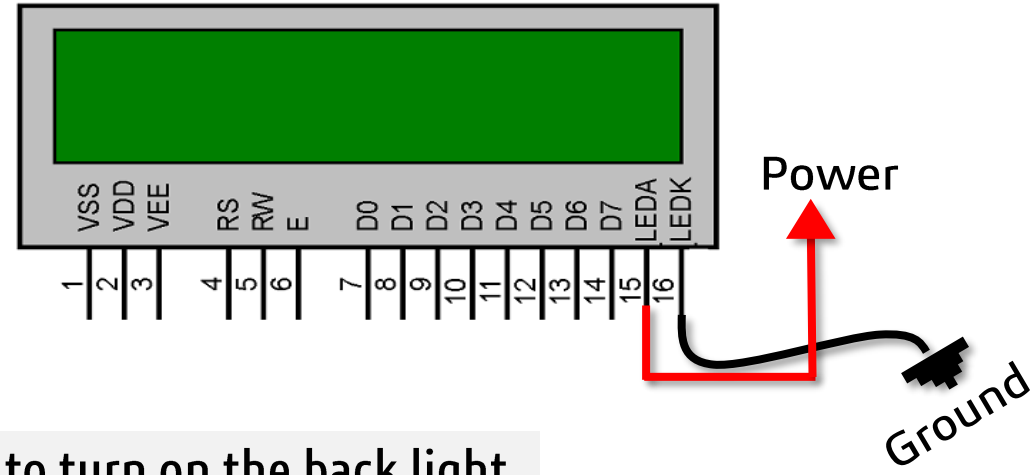


- **Data Pins**
  - **D7.....D0**
    - These pins are used to **send**/**receive** one byte **from**/**to** LCD
    - Each pin number indicates to the bit order that must be transferred on it
    - So, **b0** of data on **D0** pin. **b1** of data on **D1** pin. and so on.....,

Bi-Directional
data/Command

Character LCD lm01602A

Pins Description



Back Light Pins

- **A Pin** This pin is connected to the power source **(5V)** to turn on the back light
- **K Pin** This pin is connected to the power sink **(0V)** to turn on the back light

Character LCD lm01602A

How LCD Works

LCD is integrated with a separated computing system which its function is to display on LCD.

So, it has a processor, a memory and I/O peripherals.

This computing system communicates with others by parallel connection through data pins

LCD has three types of memory

- DDRAM — Data Display RAM
- CGRAM — Character Generator RAM
- CGROM — Character Generator ROM

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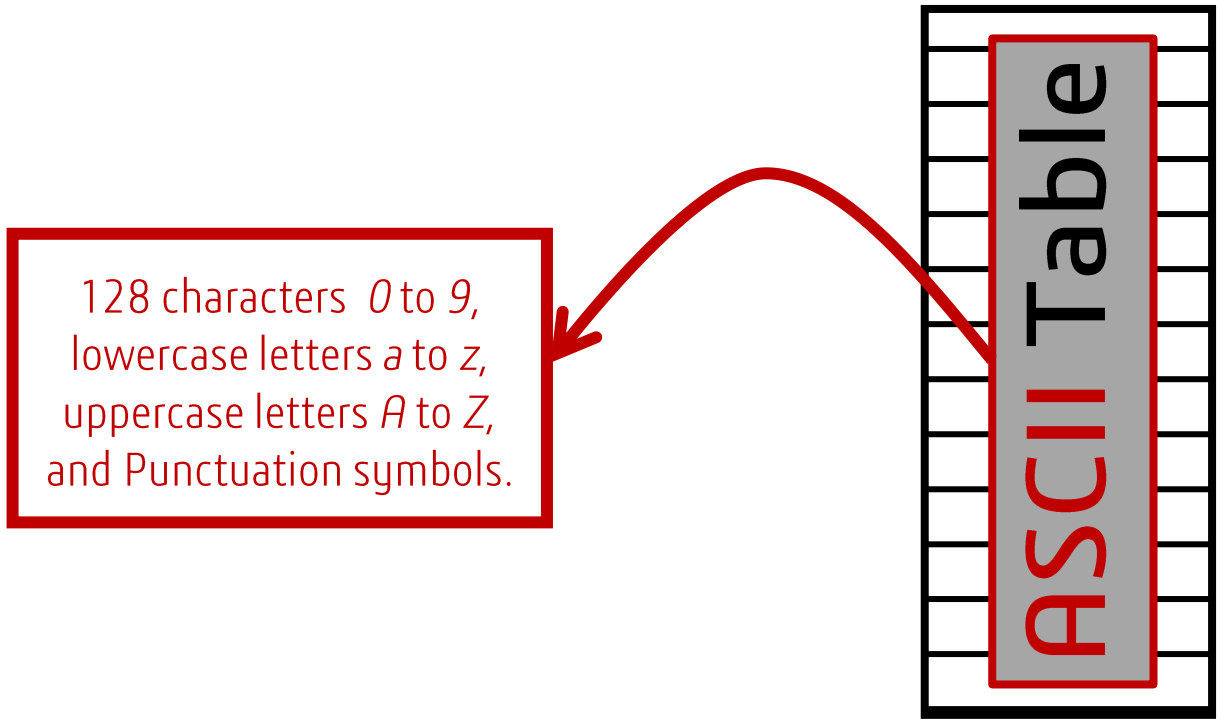
Character LCD lm01602A

Memories

1 DDRAM

- This memory is used for displaying
- When you send the character ASCII value, it will be stored into DDRAM
- After fetching its pattern, DDRAM will display the pattern on the LCD



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Character LCD lm01602A

Memories

2 CGRAM

- It is memory which is used to draw any pattern did not exist into the **CGROM**

- It is a **free memory** used to display extra characters, the designers also included the CGRAM – a small number of characters **(typically 8)** that can be redefined at run-time

- Can be used to make **small animations**, **bar graphs**, and similar **small graphic** or **sprite images**

- This memory is **RAM** not **ROM**, because ROM memory is a read-only memory for processors

- So, RAM is the excellent choice

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Character LCD lm01602A

Memories

3 CGROM

- Because of English is the most common language used around the world in addition to **ASCII standards** also, all of **ASCII** characters' patterns have been stored into **CGROM**
- So, you can now only send the address of the pattern what you want to display
- To be easier, **CGROM** is manufactured to store the pattern of characters into addresses that equalize with character **ASCII number**

Character LCD lm01602A

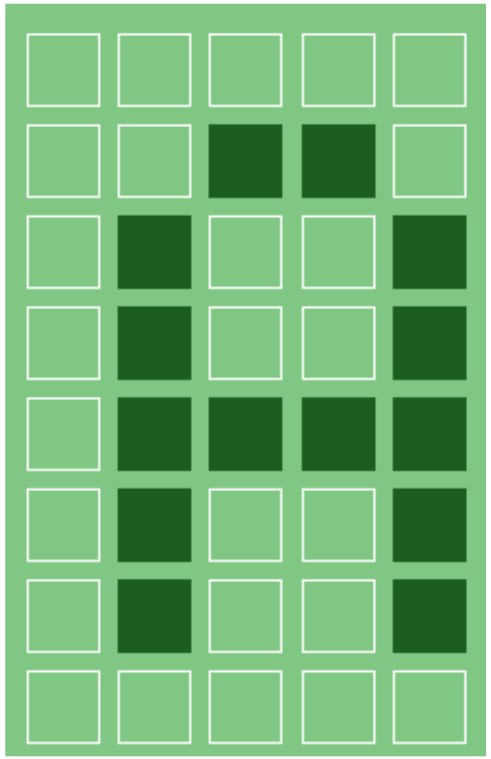
Now as an example to display 'A' Character, you can only send its ASCII number and the processor will Display the 'A' Pattern.

To Display **any Character** on LCD, the Character Must be drawn on the pixels into the pattern, each pattern on Our LCD is drawn by eight bytes

Every row is drawn by the least five bits in every byte

So, any character is drawn at least by eight bytes.

Till now, you must send the eight bytes to display 'A' Character as example on LCD: { 0x00, 0x06, 0x09, 0x09, 0x0F, 0x09, 0x09, 0x00 };



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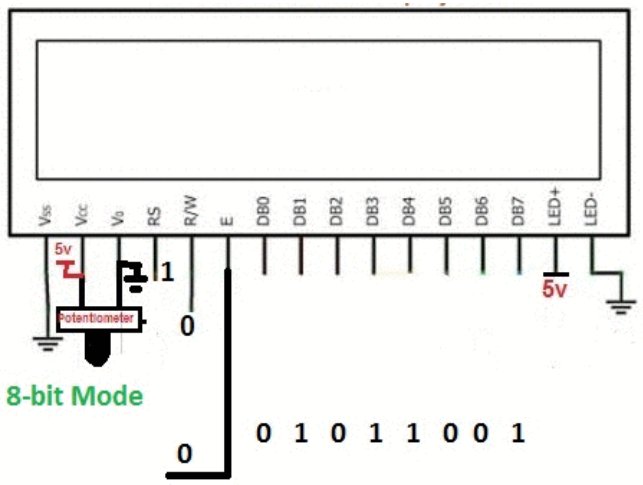
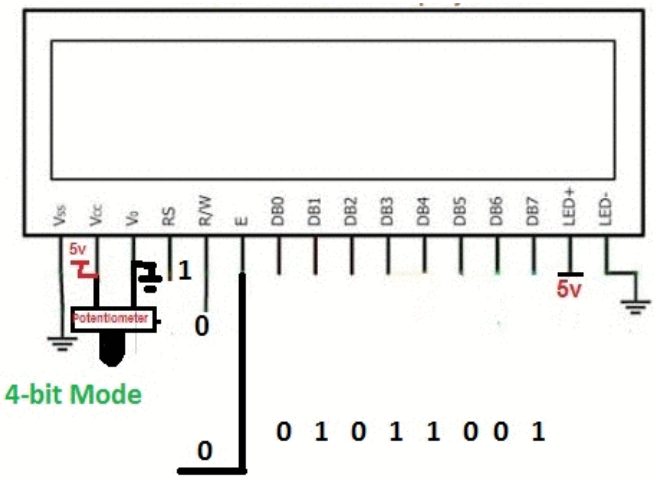
LCD lm01602A Modes

8-Bit



Here we will connect **8 wires** to all the data pins from **D0 --> D7**

4-Bit



Here we will connect only to all the data pins **4 wires (D4 --> D7)**

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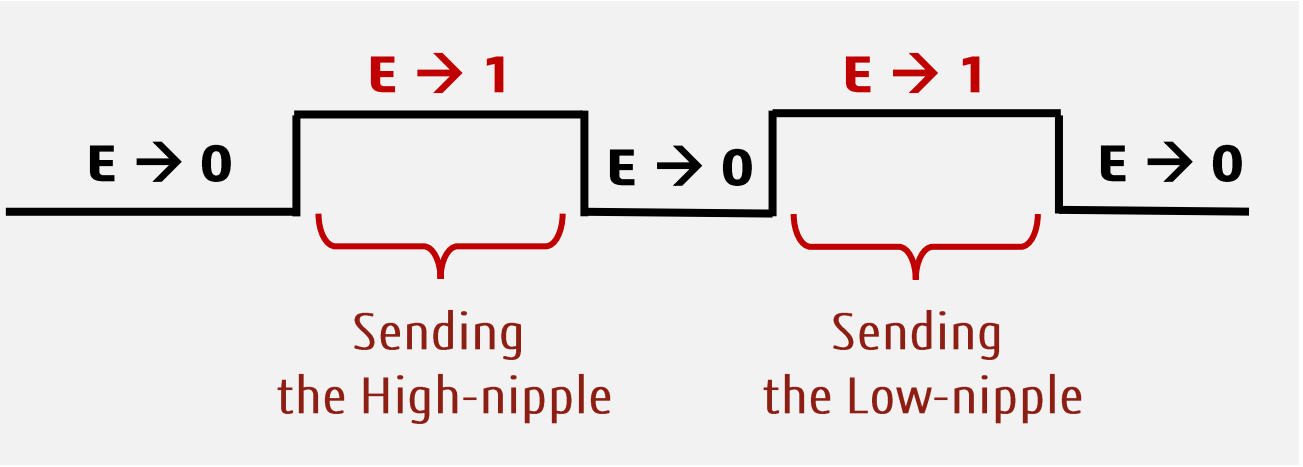
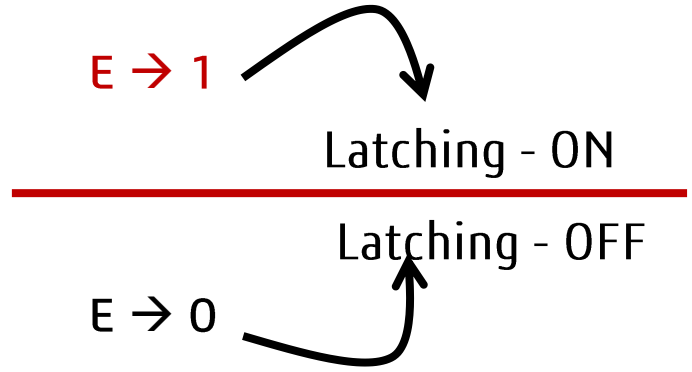
4 – Bit Mode

How 4-Bit Mode Works

When you want use the 4-bit mode, we will have to send / recive a **data** / **command** **"8 bits"** 4 by 4
So we will divide the data into two sections **"Nipples"**
a **High** nipple and a **Low** nipple





4 – Bit Mode

EXAMPLE

Sending the High nipple

Cmd = 0X28

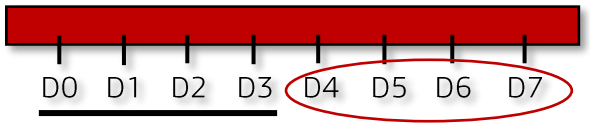
0010 ← H L → 1000

PORTA = (Cmd & 0XF0) | (PORTA & 0X0F)

0010 1000 &
1111 0000

0010 0000

PORTA



PORTA

0000 1111 &
D3 D2 D1 D0
0000 1111

0000 1111

0010 0000 |
0000 1111

0010 1111

The High Nipple

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LCD_DRIVER

Initialize LCD

1 After power on, you must delay for more than **30 MS** until **VDD** pin reaches **4.5 volt**

Now, send the Function Set Command to LCD:

Function Set									
RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	1	DL	N	F	X	X

RS : R/W are pulled down to write a command to LCD

Write **001** on **D7**,**D6**,**D5** respectively

DL: Data Length, write **one** for **Eight-bits Mode**, **Zero** for **Four-bits Mode**.

N : Number of Lines, write one for two-line activation and Zero for one-line activation. F: Font size, write one for 5x11-dot activation, and Zero for 5x8-dot activation, but our LCD has 5x8 only. D1,D0 values are not imported in this command.

0 0 1 1 1 0 0 0
for Eight-bit Mode, 2 lines , 5x8 dots
0 0 1 0 1 0 0 0
for Four-bit Mode, 2 lines , 5x8 dots

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Initialize LCD

2 **After sending function set,** you must delay for more than **39 US**

Now, Send the Display-Control Command to LCD:

RS: **R/W** are pulled down to write a command to LCD

Write **00001** on **D7**,**D6**,**D5**,**D4**,**D3** respectively

D: Display **ON/OFF**, write **One** for Enabling Display and **Zero** for Disabling Display

C: Cursor **ON/OFF**, write **One** for Cursor activation and **Zero** for Cursor Deactivation

B: **Cursor Blinking**, write **One** for Blinking activation and **Zero** for Blinking Deactivation

0 0 0 0 1 1 1 1

for Display ON, Cursor ON, Blinking ON

Initialize LCD

3 **After sending Display Control,** you must delay for more than **39 US**.
Now, Send the Display Clear Command to LCD:

RS: R/W are pulled down to write a command to LCD.
Write 0000001 on **D7,D6,D5,D4,D3,D2,D1,D0** respectively
This Command is used to **clear** the Display

Display Clear									
RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	0	0	0	0	0	1

0 0 0 0 0 0 0 1
for Display ON, Cursor ON, Blinking ON

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Initialize LCD

0 0 0 0 0 1 1 0

for Increase(to right), No Shifting

4 **After sending Display Clear,** you must delay for more than **1.53 MS**

Now, Send the Display-Control Command to LCD:

Entry Mode Set									
RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
0	0	0	0	0	0	0	1	I/D	SH

RS: **R**/W are pulled down to write a command to LCD

Write **000001** on **D7**,**D6**,**D5**,**D4**,**D3**,**D2** respectively

I/D: **Increases** (I/D = 1) or **decreases** (I/D = 0) the **DDRAM** address by **1** when a character code is written into or read from the **DDRAM**

The cursor or blink moves to the right when it be increased by **1** and to the left when it be decreased by **1**
The same applies for writing and reading the **CGRAM**

SH: Cursor **ON**/**OFF**, write **One** for Cursor activation and **Zero** for Cursor Deactivation

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LCD_DRIVER

Software Driver of the LCD

The functionality of Initial function

To be ready to run as we mentioned before

- It sets the directions of all pins connected to LCD for Output

- It sets all steps of initialization that mentioned before

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LCD_DRIVER

Software Driver of the LCD

The functionality of Send Data function

- It sets the RS pin to High, R/W to Low because of sending data
- It sets all data pins of LCD to its bit into data
- It generates the Latched Pulse on EN pin

LCD_DRIVER

Software Driver of the LCD

The functionality of Send Command function

- It sets the RS pin to Low and R/W to Low because of sending a Command
- It sets all data pins of LCD to its bit into Command
- It generates the Latched Pulse on EN pin

THANK YOU!

AMIT