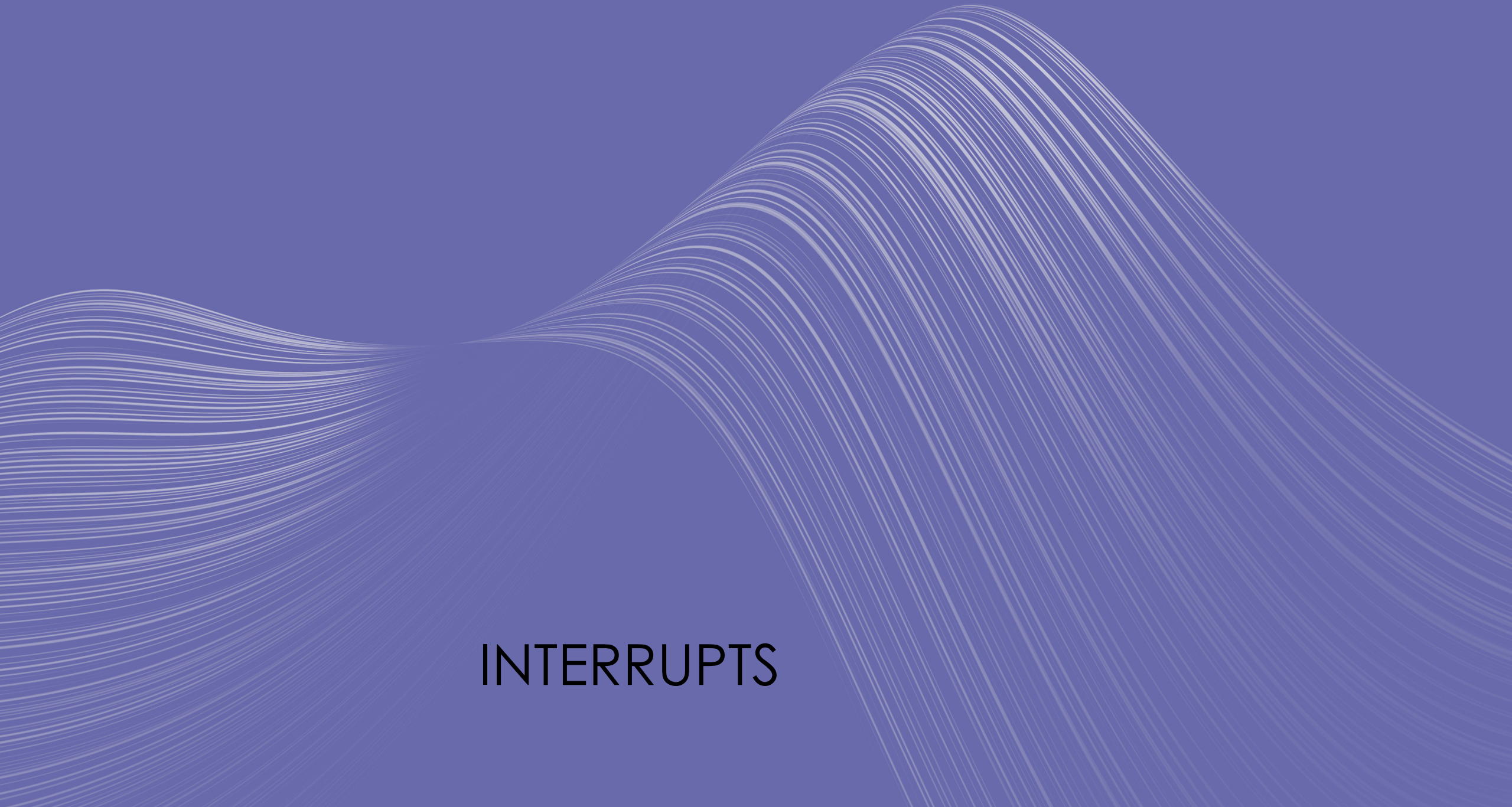


INTERRUPTS

INTERRUPTS

- Interrupts are used for communication between the microcontroller and the external device(s).
- 8051 microcontroller can recognize **six** different types of events.
- The microcontroller stops performing the current program temporarily and makes time to execute a special code.
- The interrupts sources present in 8051 microcontrollers are:
  - **Reset** interrupt
  - **Timer0** overflow interrupts TF0
  - **Timer1** overflow interruptTF1
  - **External** hardware interrupt INT0
  - **External** hardware interrupt INT1
  - **Serial communication** interrupt (RI/TI)

INTERRUPTS

- **Timers** and Serial interrupts are internally generated by the microcontroller.
- The external interrupts are generated when externally interfacing devices or switches are connected to the microcontroller.
- These external interrupts can be edge-triggered or level triggered.

8051 MICROCONTROLLER INTERRUPT SERVICE

- A fixed memory area is assigned for each interrupt inside the microcontroller.
- The **Interrupt Vector Table** contains the starting address of the memory location of every interrupt.
- The controller transfers the content of the program counter onto the stack when the interrupt occurs.
- It jumps to the memory location which is specified by **Interrupt Vector Table (IVT).**
- The code i.e., Interrupt Service Routine (ISR) written on that memory area by the programmer starts its execution

INTERRUPT VECTOR TABLE

Interrupts	Memory Location	Pin	Flag Clearing
Reset	0000	9	Auto
Timer0	000B		Auto
Timer1	001B		Auto
INT0	0003	12	Auto
INT1	0013	13	Auto
Serial com	0023		Cleared by programmer

- **RESET INTERRUPT:** When the reset pin is activated, the program execution flow jumps to execute code from the 0000H memory location. Mostly it is not used. It is also known as power-on reset.
- **TIMER INTERRUPTS:** Two timers (T0 and T1) are present in the 8051 microcontroller responsible for a Timer interrupt.
  - A timer interrupt informs the microcontroller that the corresponding Timer has finished the counting. Memory locations 000BH and 001BH in the interrupt vector table belong to Timer0 and Timer1 respectively.
- **EXTERNAL INTERRUPTS:** There are two external interrupts (INT0 and INT1) to serve external devices.
  - An external interrupt informs the microcontroller that an external device needs its routine service. Memory locations 0003H and 0013H in the interrupt vector table belong to INT0 and INT1 respectively.
- **SERIAL INTERRUPT:** This interrupt is used for serial communication. It has a single interrupt that belongs to both receives and transmits.
  - When enabled, it notifies the controller whether a byte has been received or transmitted. The interrupt vector table location 0023H belongs to this interrupt.

INTERRUPTS ENABLE (IE) REGISTER

- All the interrupts discussed in the previous slide can be used by configuring some bit in a special function register known as **Interrupt Enabled (IE) register.**
- These registers enable or disable the various available interrupts.

INTERRUPTS ENABLE (IE) REGISTER

EA	-	ET2	ES	ET1	EX1	ET0	EX0

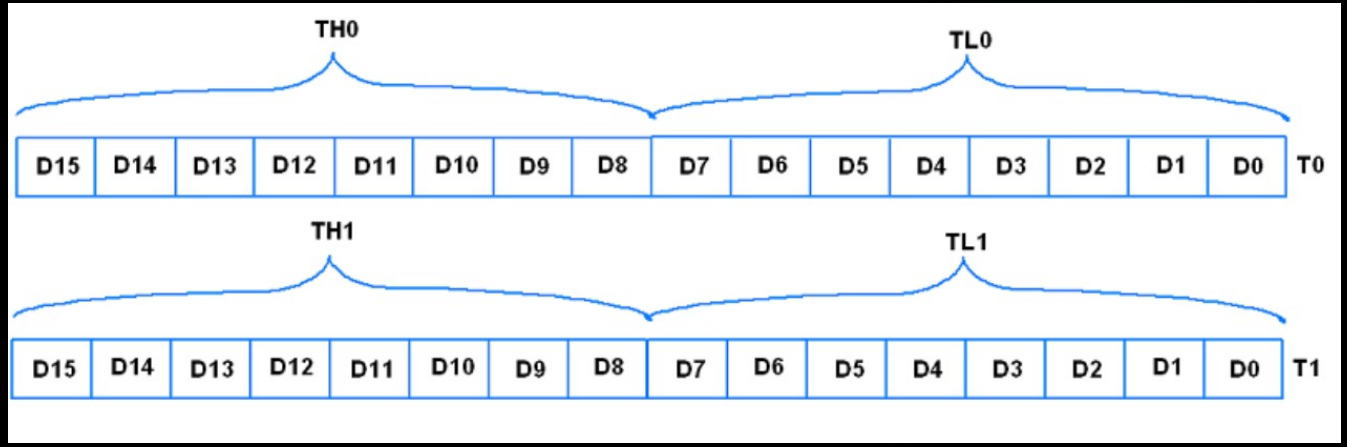
- **EA – Enable Interrupt:** EA bit must be set to 1 to enable any of the interrupts.
  - By default, all the interrupts are in disabled mode. if EA = 1 Enable Interrupt and if EA = 0 Disable Interrupt
- **ET2 – Timer2 interrupt enable bit**: Enable or disable Timer2 overflow or capture interrupt only in 8052. In AT89C51, there are only two timers, so ET2 is not used.
- **ES – Serial port interrupt enable bit:** Enable or disable Serial port interrupt.
- **ET1 -Timer1 interrupt enable bit:** If ET0 = 1, Enable Timer1 overflow interrupt and if ET0 = 0, Disable Timer1 overflow interrupt.
- **EX1- External interrupt INT1 enable bit :** If EX1 = 1, Enable INT1 and if EX1 = 0, Disable INT1
- **ET0: Timer0 interrupt enable bit:** ET0 = 1, Enable Timer0 overflow interrupt ET0 = 0, Disable Timer0 overflow interrupt
- **EX0: External interrupt INT0 enable bit:** If EX1 = 1, Enable INT0 EX1 = 0, Disable INT0

INTERRUPT SERVICE ROUTINE (ISR)

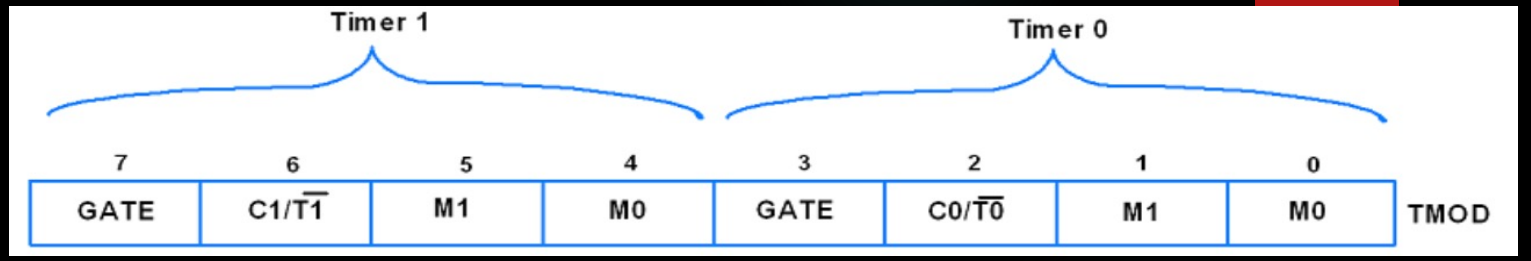
- What to do when an interrupt occurs?
  - We write a subroutine or function for the interrupt which is the ISR. It is automatically called when an interrupt occurs.
- **External Interrupts:**
  - External interrupts are received from the external interfaced devices at INTx pins of the microcontroller.
  - These can be level-triggered or edge-triggered which is decided by the **TCON** register.

8051 TIMERS

- 8051 microcontrollers have two timers/counters which work on the clock frequency.
- **Timer/counter** can be used for time delay generation, counting external events, etc.
- Both the two timers Timer0 (T0) and Timer1 (T1), are 16-bit wide



8051 TIMERS



- 8051 has a **Timer Mode Register (TMOD)** and **Timer Control Register (TCON)** for selecting a mode of operation and controlling purpose.

TMOD register:

- TMOD is an 8-bit register used to set the timer mode of timer0 and timer1.

Bit 7,3 – GATE:

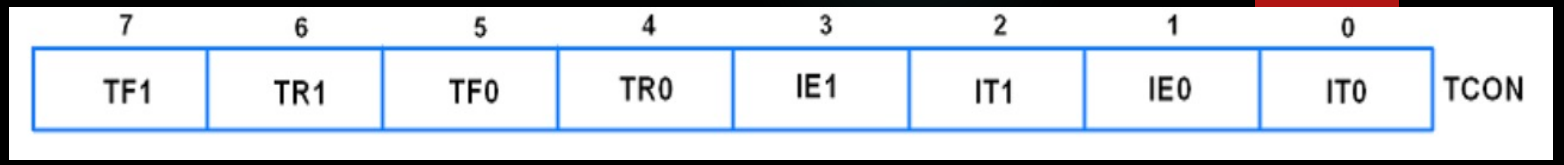
1 = Enable Timer/Counter only when the INT0/INT1 pin is high and TR0/TR1 is set.

0 = Enable Timer/Counter when TR0/TR1 is set.

Use as Counter
Use as Timer

M1	M0	Mode	Operation
0	0	0 (13-bit timer mode)	13-bit timer/counter, 8-bit of THx & 5-bit of TLx
0	1	1 (16-bit timer mode)	16-bit timer/counter, THx cascaded with TLx
1	0	2 (8-bit auto-reload mode)	8-bit timer/counter (auto-reload mode), TLx reload with the value held by THx each time TLx overflow
1	1	3 (split timer mode)	Split the 16-bit timer into two 8-bit timers i.e. THx and TLx like two 8-bit timer

TCON REGISTER



TCON is an 8-bit control register and contains a timer and interrupt flags.

Bit 7 - TF1: Timer1 Overflow Flag
1 = Timer1 overflow occurred (i.e. Timer1 goes to its max and roll over back to zero).
0 = Timer1 overflow not occurred.

Bit 6 - TR1: Timer1 Run Control Bit
1 = Timer1 start.
0 = Timer1 stop.

Bit 5 – TF0: Timer0 Overflow Flag
1 = Timer0 overflow occurred (i.e. Timer0 goes to its max and roll over back to zero).
0 = Timer0 overflow not occurred.

Bit 4 – TR0: Timer0 Run Control Bit
1 = Timer0 start.
0 = Timer0 stop.

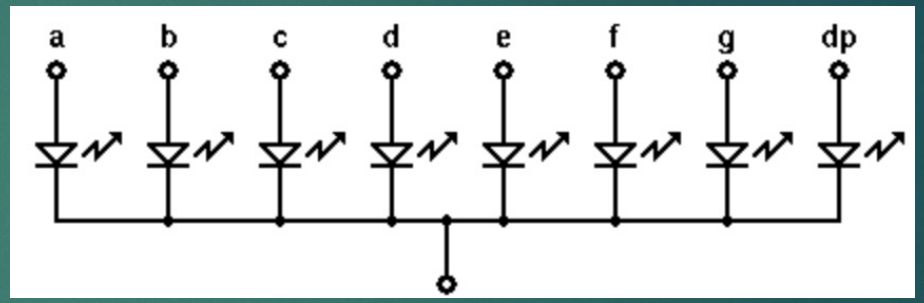
Bit 3 - IE1: External Interrupt1 Edge Flag
1 = External interrupt1 occurred.
0 = External interrupt1 Processed

Bit 2 - IT1: External Interrupt1 Trigger Type Select Bit
1 = Interrupt occurs on falling edge at INT1 pin.
0 = Interrupt occur on a low level at the INT1 pin.

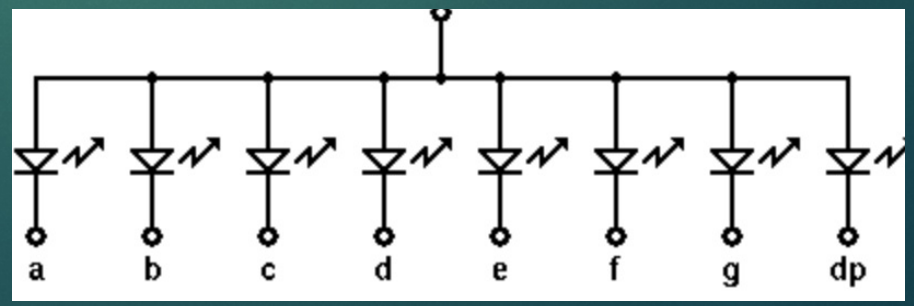
LAB # 05
SEVEN SEGMENT DISPLAY

SEVEN SEGMENT DISPLAY

- Seven segment displays internally consist of 8 LEDs.
- **7 LEDs** are used to indicate the digits 0 to 9 and a single LED is used for indicating a decimal point.
- Seven segments are of two types.
  - **Common cathode:**
    - In a common cathode, all the cathodes of LEDs are tied together and labeled as com, and anodes are left alone.



  - **Common anode:**
    - In a common anode, a seven-segment display all the anodes are tied together, and cathodes are left freely.



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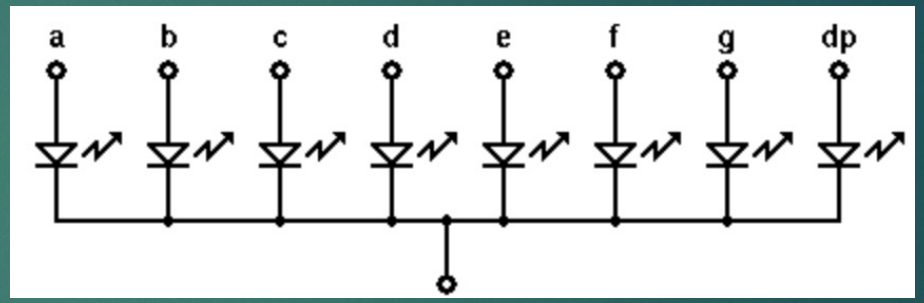

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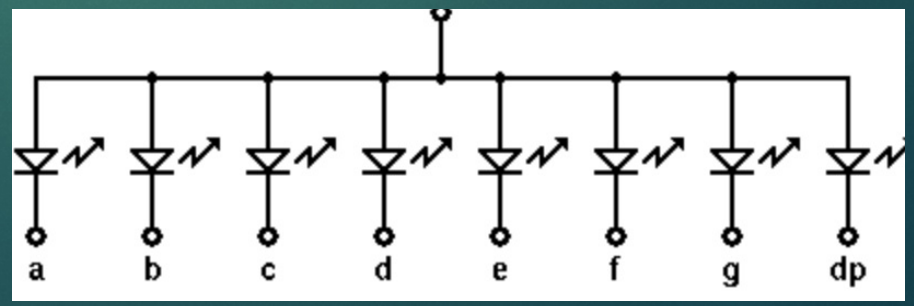

COMMON CATHODE DISPLAY

DIGIT	DP	G	F	E	D	C	B	A	HEX VALUE
0	0	0	1	1	1	1	1	1	0x3f
1	0	0	0	0	0	1	1	0	0x06
2	0	1	0	1	1	0	1	1	0x5b
3	0	1	0	0	1	1	1	1	0x4f
4	0	1	1	0	0	1	1	0	0x66
5	0	1	1	0	1	1	0	1	0x6d
6	0	1	1	1	1	1	0	1	0x7d
7	0	0	0	0	0	1	1	1	0x07
8	0	1	1	1	1	1	1	1	0x7f
9	0	1	1	0	0	1	1	1	0x67