Embedded System on AVR Microcontroller (ATMEGA32)

Exp2: Digital Output through 7 segment LED display to increment and decrement the number with SRAM memory mapping

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January, 2024

- # Seven Segment LED Display

Light Emitting Diode (LED) is the most widely used semiconductor which emits either visible light or invisible infrared light when forward biased. A Light-emitting diode (LED) is optical-electrical energy into light energy when voltage is applied. A seven-segment LED is a digital display module specialized to display numerical information. Light-emitting diodes (LEDs) arranged in the shape of numbers offer an easily visible display. They are sometimes called "seven-segment displays" or "seven-segment indicators."

The 7-segment display consists of seven LEDs (hence its name) arranged in a rectangular fashion as shown. Each of the seven LEDs is called a segment because when illuminated the segment forms part of a numerical digit (both Decimal and Hex) to be displayed.

An additional 8th LED is sometimes used within the same package thus allowing the indication of a decimal point, (DP) when two or more 7-segment displays are connected together to display numbers greater than ten.

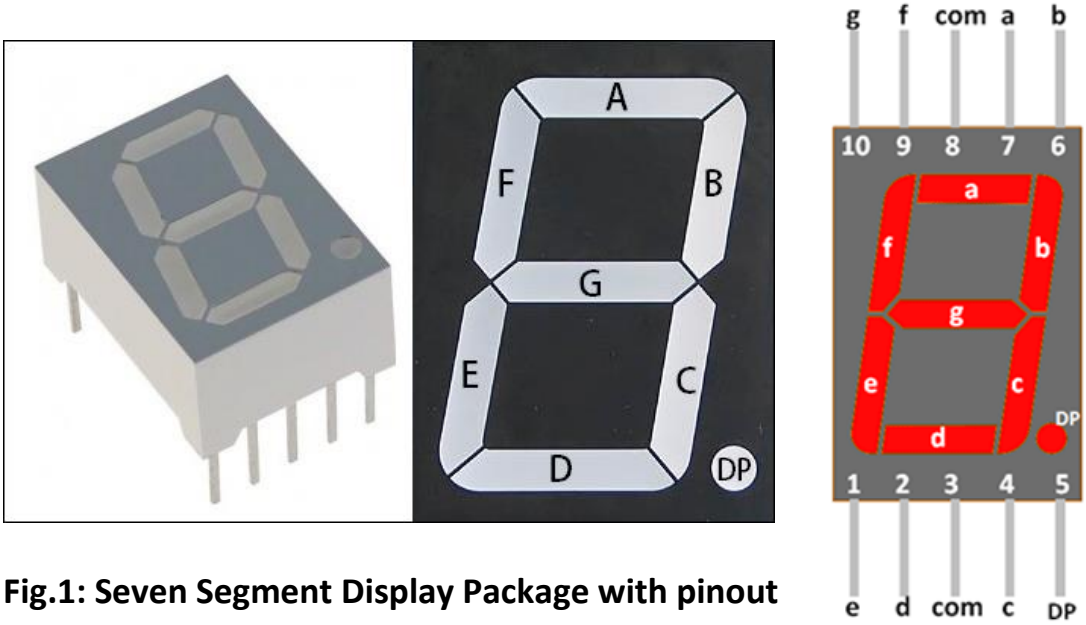
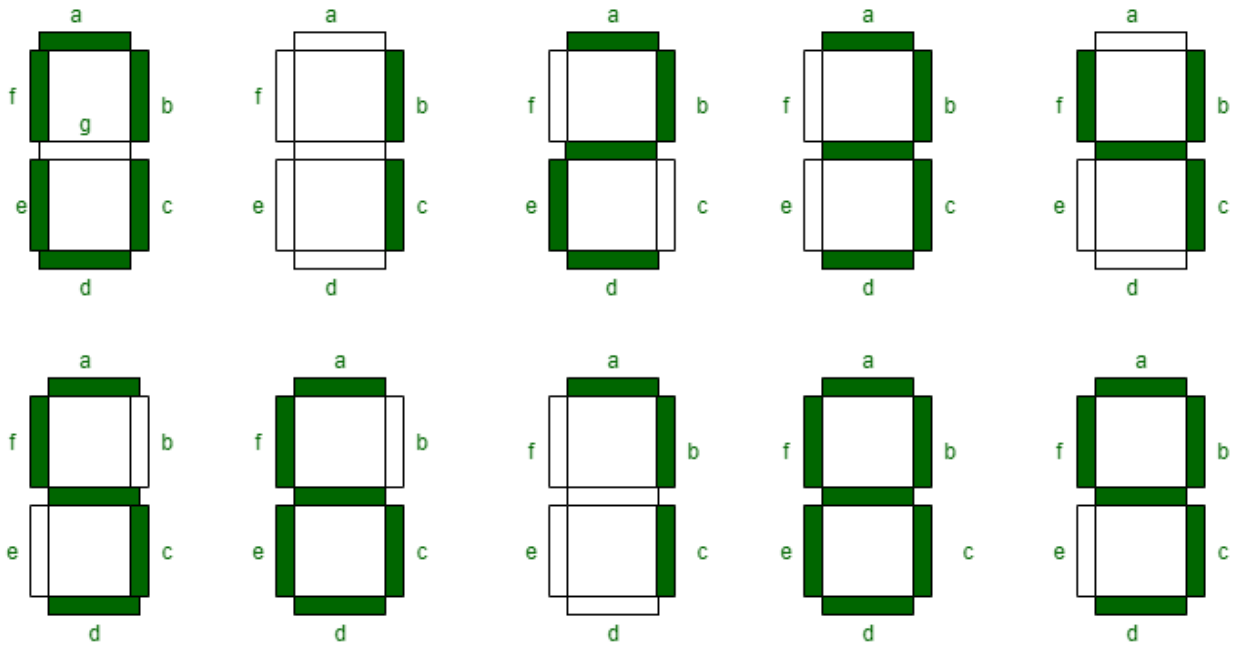


Fig.1: Seven Segment Display Package with pinout

The parts of the seven-segment LED are as follows:

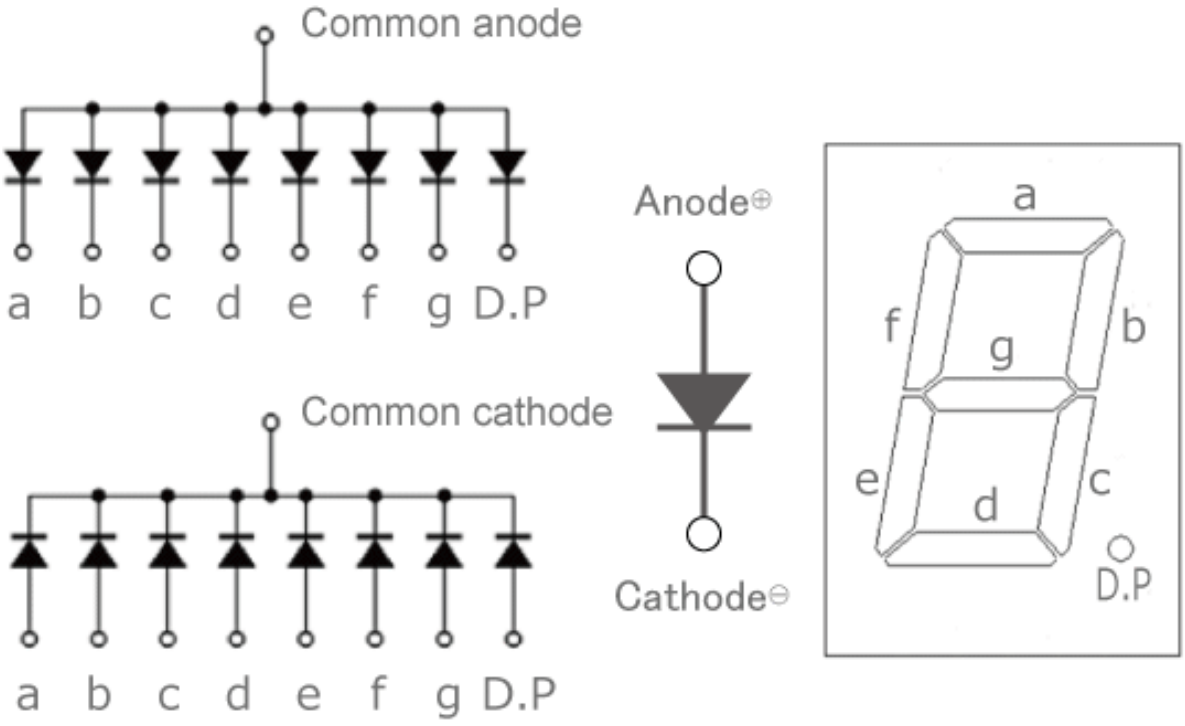
I. **Light-emitting components (a–g): 7 Segments (Seg)**
II. **Dot light-emitting component: Decimal point (DP)**
III. **Common LED Pins: 2 pins from same common node**

So by forward biasing the appropriate pins of the LED segments in a particular order, some segments will be light and others will be dark allowing the desired character pattern of the number to be generated on the display. This then allows us to display each of the ten decimal digits 0 through to 9 on the same 7-segment display.



As each LED has two connecting pins, one called the “Anode” and the other called the “Cathode”, there are therefore two types of LED 7-segment display called: Common Cathode (CC) and Common Anode (CA). The displays common pin is generally used to identify which type of 7-segment display it is.

Common Cathode (CC): In the common cathode display, all the cathode connections of the LED segments are joined together to logic “0” or ground. The individual segments are illuminated by application of a “HIGH”, or logic “1” signal via a current limiting resistor to forward bias the individual Anode terminals (a-g).



Common Anode (CA): In the common anode display, all the anode connections of the LED segments are joined together to logic "1". The individual segments are illuminated by applying a ground, logic "0" or "LOW" signal via a suitable current limiting resistor to the Cathode of the particular segment (a-g).

In the LAB, the Common Cathode(CC) Seven Segment Display is used for the experiment purpose.

- **Truth Table for Common Cathode Display**

0 -- 0X3F

Decimal Digit	Individual Segments Illuminated						
	a	b	c	d	e	f	g
0	1	1	1	1	1	1	0
1	0	1	1	0	0	0	0
2	1	1	0	1	1	0	1
3	1	1	1	1	0	0	1
4	0	1	1	0	0	1	1
5	1	0	1	1	0	1	1
6	1	0	1	1	1	1	1
7	1	1	1	0	0	0	0
8	1	1	1	1	1	1	1
9	1	1	1	1	0	1	1

Therefore, Boolean expressions for each decimal digit that requires respective light-emitting diodes (LEDs) are ON or OFF. Seven segment displays must be controlled by other external devices where different types of microcontrollers are useful to communicate with these.

- **Seven Segment LED Display to Increment the Number Memory Mapped SRAM**

```
// Seven Segment Display Increment

.INCLUDE "M32DEF.INC"
.ORG 0X0000

LDI R16,HIGH(RAMEND)
OUT SPH,R16
LDI R16,LOW(RAMEND)
OUT SPL,R16

LDI R16,0x3F //Seven Segment Bits for 0
MOV R0,R16

LDI R16,0x06 //Seven Segment Bits for 1
MOV R1,R16

LDI R16,0x5B //Seven Segment Bits for 2
MOV R2,R16

LDI R16,0x4F //Seven Segment Bits for 3
MOV R3,R16

LDI R16,0x66 //Seven Segment Bits for 4
MOV R4,R16

LDI R16,0x6D //Seven Segment Bits for 5
MOV R5,R16

LDI R16,0x7D //Seven Segment Bits for 6
MOV R6,R16

LDI R16,0x07 //Seven Segment Bits for 7
MOV R7,R16

LDI R16,0x7F //Seven Segment Bits for 8
MOV R8,R16

LDI R16,0x6F //Seven Segment Bits for 9
MOV R9,R16
```

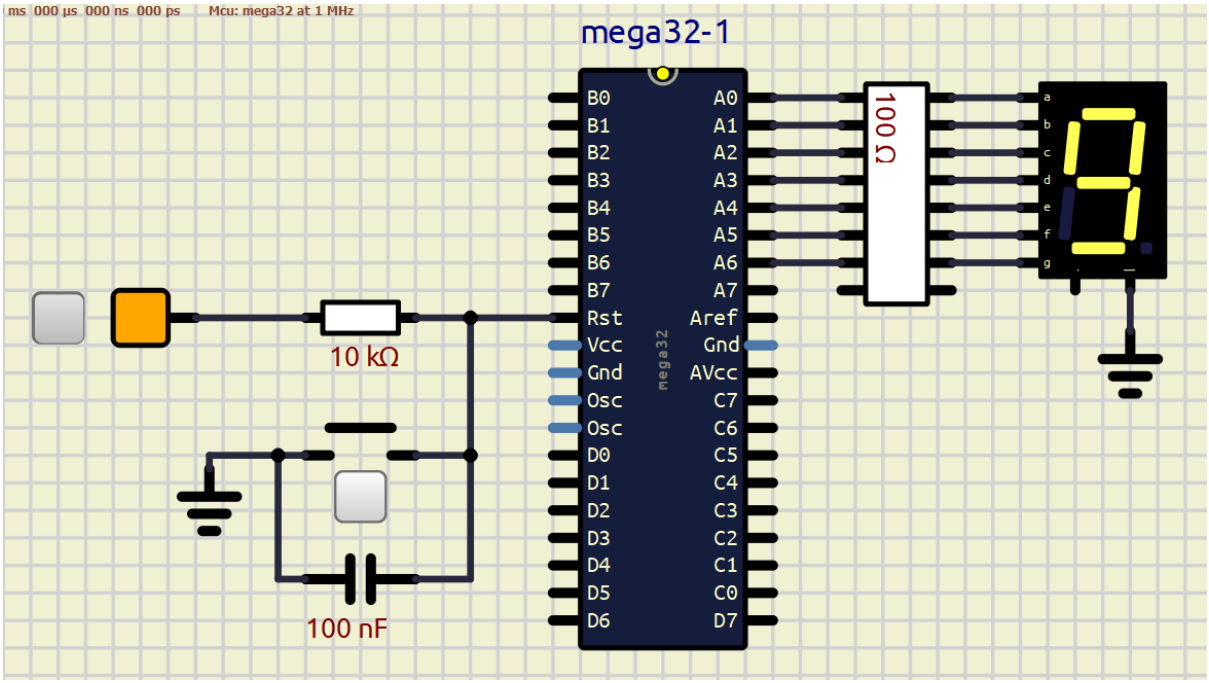
```
LDI R16,0XFF
OUT DDRA,R16

LDI R27,0x00; // XH of the register pair X
LDI R26,0x00; // XL of the register pair X

MAIN:     LD R16,X+
          OUT PORTA,R16
          CALL Delay
          CPI R26,0x0A
          BRNE MAIN
          LDI R26,0x00
          JMP MAIN

Delay:    LDI R17,0xFF
          L1:  LDI R18,0xFF
          L2:  LDI R19,0x04
          L3:  NOP
               DEC R19
               BRNE L3
               DEC R18
               BRNE L2
               DEC R17
               BRNE L1
               RET
```

- **Instruction Sets of ATmega32**
  http://www.avr-asm-tutorial.net/avr_en/micro_beginner/instructions.html

- **Make the below Circuit on SimulIDE to simulate**

Components Required:

1. ATmega32
2. Seven Segment LED Display
3. 100 Ohm DIP Resistor
4. Fixed Voltage
5. Push Button
6. 10KOhm Resistor
7. 100nF Capacitor



After uploading the HEX file, verify the simulation by TA.

Assignment1: Write the C code for the above Experiment

- **Seven Segment LED Display to Decrement the Number Memory Mapped SRAM**

```
// Seven Segment Display Decrement

.INCLUDE "M32DEF.INC"
.ORG 0X0000

LDI R16,HIGH(RAMEND)
OUT SPH,R16
LDI R16,LOW(RAMEND)
OUT SPL,R16

LDI R16,0x3F //Seven Segment Bits for 0
MOV R0,R16

LDI R16,0x06 //Seven Segment Bits for 1
MOV R1,R16

LDI R16,0x5B //Seven Segment Bits for 2
```

```
MOV R2,R16

LDI R16,0x4F //Seven Segment Bits for 3
MOV R3,R16

LDI R16,0x66 //Seven Segment Bits for 4
MOV R4,R16

LDI R16,0x6D //Seven Segment Bits for 5
MOV R5,R16

LDI R16,0x7D //Seven Segment Bits for 6
MOV R6,R16

LDI R16,0x07 //Seven Segment Bits for 7
MOV R7,R16

LDI R16,0x7F //Seven Segment Bits for 8
MOV R8,R16

LDI R16,0x6F //Seven Segment Bits for 9
MOV R9,R16

LDI R16,0XFF
OUT DDRA,R16

LDI R27,0x00; // XH of the register pair X
LDI R26,0x0A; // XL of the register pair X

MAIN:     LD R16,-X
          OUT PORTA,R16
          CALL Delay
          CPI R26,0X00
          BRNE MAIN
          LDI R26,0x0A
          JMP MAIN

Delay:    LDI R17,0xFF
          L1:  LDI R18,0xFF
          L2:  LDI R19,0x04
          L3:  NOP
               DEC R19
```

```
BRNE L3
DEC R18
BRNE L2
DEC R17
BRNE L1
RET
```

Upload the HEX file in the same circuit on SimulIDE discussed above and verify the simulation by TA.

Assignment2: Write the C code for the above Experiment

- **A Real-Time Example: Road Traffic Signaling**

```
// Road Traffic  Signaling

.INCLUDE "M32DEF.INC"
.ORG 0X0000

LDI R16,HIGH(RAMEND)
OUT SPH,R16
LDI R16,LOW(RAMEND)
OUT SPL,R16

LDI R16,0x3F //Seven Segment Bits for 0
MOV R0,R16

LDI R16,0x06 //Seven Segment Bits for 1
MOV R1,R16

LDI R16,0x5B //Seven Segment Bits for 2
MOV R2,R16

LDI R16,0x4F //Seven Segment Bits for 3
MOV R3,R16

LDI R16,0x66 //Seven Segment Bits for 4
MOV R4,R16

LDI R16,0x6D //Seven Segment Bits for 5
MOV R5,R16

LDI R16,0x7D //Seven Segment Bits for 6
```

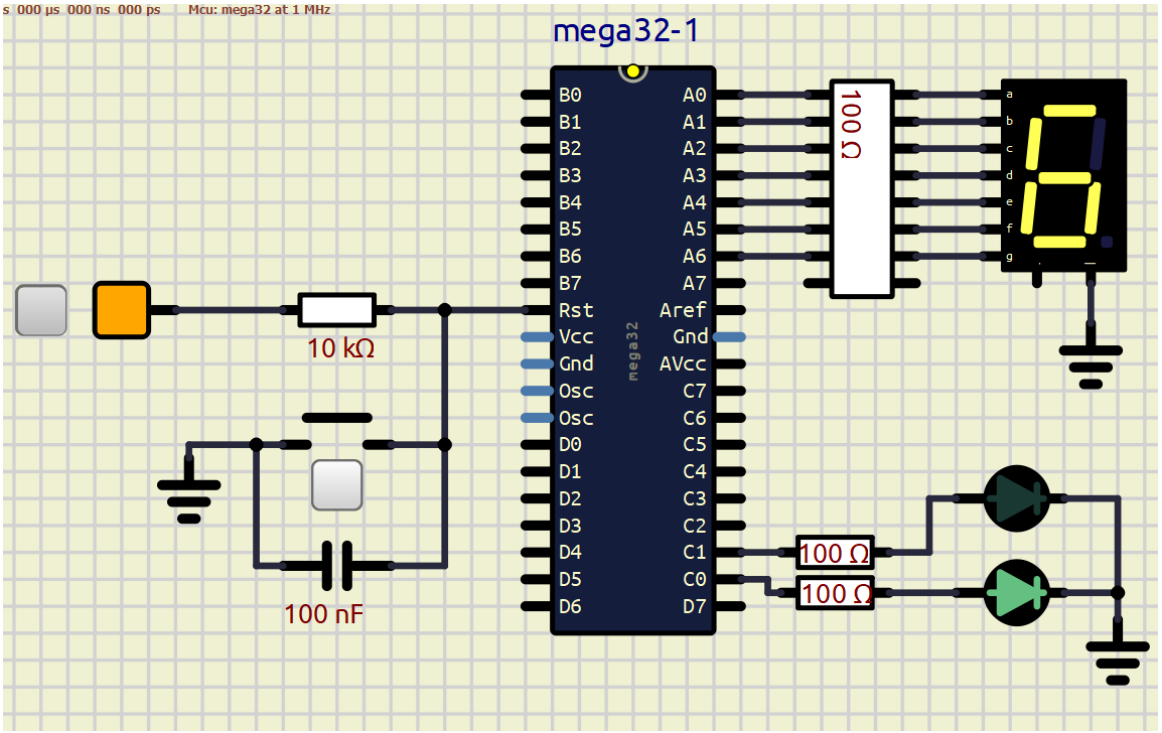
```
MOV R6,R16

LDI R16,0x07 //Seven Segment Bits for 7
MOV R7,R16

LDI R16,0x7F //Seven Segment Bits for 8
MOV R8,R16

LDI R16,0x6F //Seven Segment Bits for 9
MOV R9,R16

LDI R16,0XFF
OUT DDRA,R16  //For 7 Segment Display

LDI R16,0x03
OUT DDRC,R16  //For Signaling LEDs

LDI R27,0x00; // XH of the register pair X
LDI R26,0x0A; // XL of the register pair X

MAIN:     SBI PORTC,PINC0
          CBI PORTC,PINC1
MLOOP1:   LD R16,-X
          OUT PORTA,R16
          CALL Delay
          CPI R26,0X00
          BRNE MLOOP1
          LDI R26,0x0A

          CBI PORTC,PINC0
          SBI PORTC,PINC1
MLOOP2:   LD R16,-X
          OUT PORTA,R16
          CALL Delay
          CPI R26,0X00
          BRNE MLOOP2
          LDI R26,0x0A
          JMP MAIN

Delay:    LDI R17,0xFF
          L1:  LDI R18,0xFF
          L2:  LDI R19,0x04
```

```
L3:  NOP
     DEC R19
     BRNE L3
     DEC R18
     BRNE L2
     DEC R17
     BRNE L1
     RET
```

- **Make the below Circuit on SimulIDE to simulate**

Components Required:

1. ATmega32
2. Seven Segment LED Display
3. 100 Ohm DIP Resistor
4. Fixed Voltage
5. Push Button
6. 10KOhm Resistor
7. 100nF Capacitor
8. Two 100 Ohm Resistor
9. One Green LED
10. One Red LED



Upload the HEX file in the same circuit on SimulIDE discussed above and verify the simulation by TA.

Assignment3: Write the C code for the above Experiment

- **Hardware Simulation of Experiments**

Components Required:

1. ATmega32
2. AVR development board
3. USBasp
4. Seven Segment LED Display (Common Cathode)
5. 100 Ohm Resistors: 9Pcs
6. One Green LED
7. One Red LED
8. Bread Board
9. Jumper Wires Female to Male: 10Pcs
10. Single Stand Wires as Required

Make the circuit on bread board as the Last Experiment on SimulIDE and Flash the Microcontroller with respective HEX file.

Assignment4: Experiment on SimulIDE with Double Digit Multiplex Display for the Road Traffic Signalling to decrement the digit value from 30 to 00.