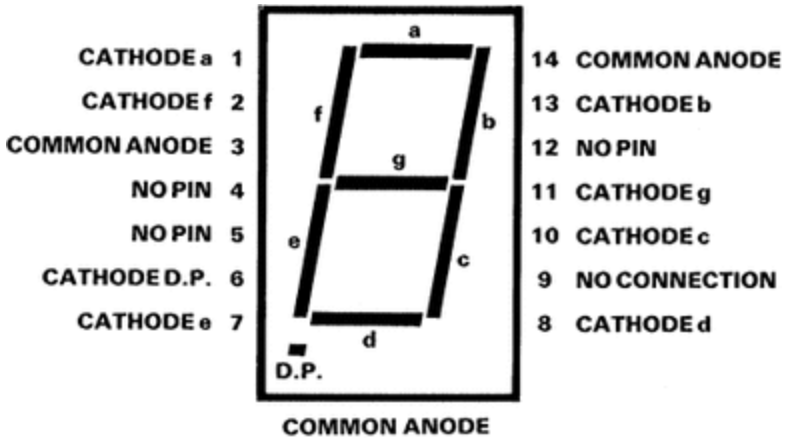
Theory of operation:

The first change in the hardware design was the removal of the pull up resistors connecting port D and Switches. The switches were directly connected to the Port D instead. To complement this action in code. The internal pull up resistors were implemented using this sequence of code, in which 1111 1111 was used to turn on the resistors in PortD:

```
ldi r16, $ff        ; load r16 and turn on all
out PortD, r16      ; the pull resistors in PortD in the chip
```

Using the built in pull up resistors helps reduce number of hardware in the circuit.

The second change in the hardware design was replacement of bargraph LEDs with 7-Segment led display(MAN72A). Unlike bargraph, 7 segment LED could be coded to output a single number or character. In order to supplement the change from the bargraph LEDs to the 7 segment display the 330 ohm sip resistors were changed to a 330 ohm dip resistors.To limit the flow of the current from LED to chip, the dip resistor is placed between the chip and display.



[1]

The 7 segment display is wired to Port B, using the table below:

bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
dp	g	f	e	d	c	b	a

[2]Since dp in the 7 segment display could be located on the right or left or both, pin 9 and pin 6 of the segment display are used accordingly. either pin 3 or 14 is connected to Vcc depending on whichever is closest to the power in the circuit.

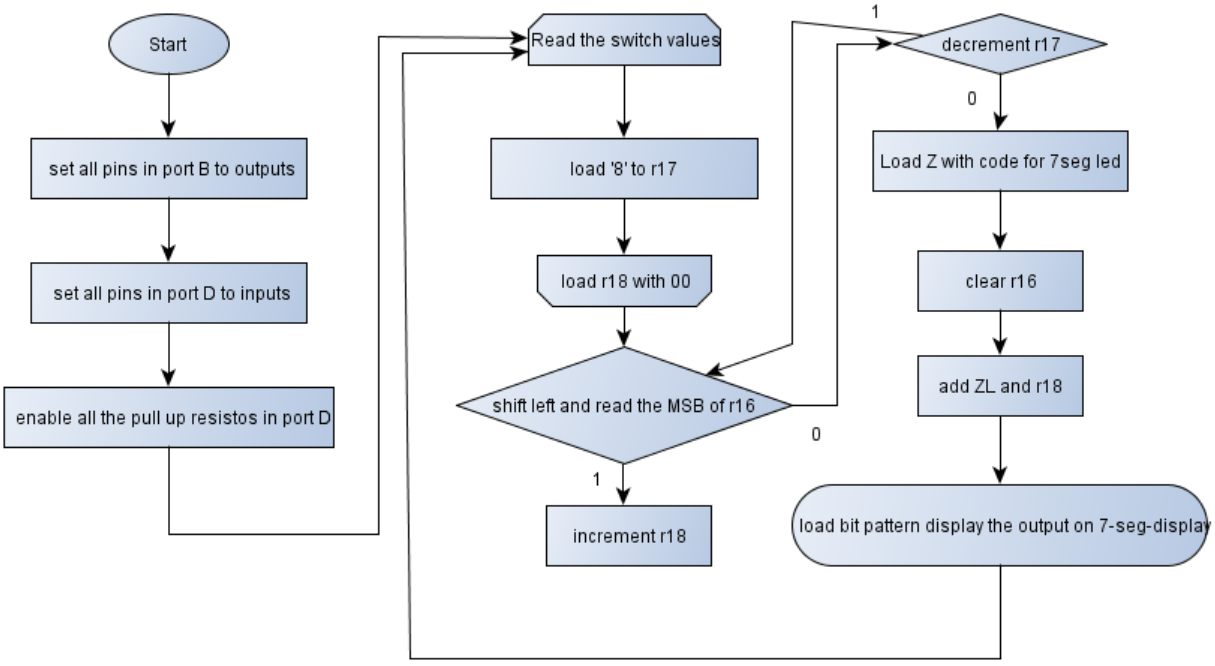
[1] image courtesy:http://brettfieldmeter.weebly.com/uploads/1/4/3/0/14307110/7852429.gif?388

[2] table courtesy: lab 3 manual, Professor Scott Tierno.

The 7 segment led can handle voltage of 6v and current of 240 mA.[3] Adding the 330 ohm resistor will bring down the current to 150mA. $I = \frac{V}{R} = \frac{5v}{330\Omega} = 151.5\ mA.$ This will prevent the LEDs from dying out.

Chips pins and ports used:

For this lab, we used Port B(1-8) as active low, to activate the led on the 7 segment display. Port D(14-21) is used as an input with pull up resistor enabled, and it is used to read the switch values. Port C(24-27) like previous labs are used for JTAG connector. A separate push buttons connects the reset pin(9), JTAG connector(6) and ground. This push button is used to reset the chip and restart the code. For this lab none of the pins in Port A(33-40) are used. Wiring of JTAG connector and switches is unchanged, except the removal of the external pull up resistor between the chip and switches.



The software used for the circuit is represent in the above flowchart. The initializing setup is same as the previous labs. r17 and r18 are initialized with 8 and $00 respectively. The values of switches are stored to register 16. Then left msb is shifted the bits in r16, thus making the msb move to the carry. If the carry is 0, register 18 is incremented. If 1, register 17 is decremented. This is repeated until r17 is 0. Z registers are setup with values of table. Table contains the code for the 7seg led. Bit pattern is identified depending on the r18. The output is then displayed on 7seg display.

[3] MAN72A datasheet

Data/ Results:

Four different programs were tested on the circuit to test the functionality of the design. The first task tested the functionality of the circuit when the external pullup resistors were removed and the internal pullup resistors were used instead. The code was programmed into the flash memory of the chip and the result was that the circuit did not act same as before for task 1(the LEDs would not light up); since the pullup resistors were removed, the wires were sensitive to our proximity and as a result we act as a ground which is what the inputs needs to output on the LEDs, which cause the LEDs to light up corresponding to the wire that was touched. Task 2 implements the pullup resistors inside the chip using code and as a result we are no longer able to affect the values and the circuit was finally working the same as before when we had the external pullup resistors. Task 3 was outputting the number of switches that were turned on using the bargraph to count, so the LEDs displayed the number of switches turned on equal to the number of LEDs turned on. The counting on the LEDs starts from the bottom up rather than corresponding to the switches. In task 4, rewiring was done to implement the 7 segment display instead of the bargraph leds. Task 5 implemented the code that would implement a counter for the number of switches turned on using the 7 segment display. Task 6 outputs a square wave using 1 and 0 outputs from portA pin40 of the Atmega chip. The given code had to changed to make the duty cycle 50% rather than 40% by adding two nops to logic 1 outputting.