Interfacing with Simple Display Devices

Lecture 4
Embedded Systems

```
#define DT 100
const int firstLed = 3;
                                                                 Adjusting the
const int secondLed = 5;
const int thirdLed = 6;
                                                         Brightness of an LED
int brightness = 0;
int increment = 1;
void setup()
      // pins driven by analogWrite do not
      // need to be declared as outputs
void loop()
      if (brightness==255) increment*=-1;
      brightness+=increment;
      analogWrite(firstLed, brightness);
      analogWrite(secondLed, brightness);
      analogWrite(thirdLed, brightness);
      delay(DT);
                                                            PB0/ICP1/CLKO/PCINT0
                                         PD0/RXD/PCINT16
                                                                              15
                                         PD1/TXD/PCINT17
                                                                PB1/OC1A/PCINT1
                                                                              16
                                         PD2/INT0/PCINT18
                                                             PB2/SS/OC1B/PCINT2
                                                                              17
                           D1 ()
                                                            PB3/MOSI/OC2A/PCINT3
                                         PD3/INT1/OC2B/PCINT19
                                                                                       D1
                                                                                               D2
                                                                                                        D3
                                                                              18
                                         PD4/T0/XCK/PCINT20
                                                                PB4/MISO/PCINT4
                                                                              19
                           D2 O
                                        PD5/T1/OC0B/PCINT21
                                                                PB5/SCK/PCINT5
                                     12
                                                                              9
                                         PD6/AIN0/OC0A/PCINT22
                                                          PB6/TOSC1/XTAL1/PCINT6
                                     13
                                                                              10
                                        PD7/AIN1/PCINT23
                                                          PB7/TOSC2/XTAL2/PCINT7
                                         AREF
                                                               PC0/ADC0/PCINT8
                                                                              24
                                                                                              R2
                                                                                                       R3
                                                                                      R1
                                         AVCC
                                                               PC1/ADC1/PCINT9
                                                                              25
                                                                                      220
                                                                                              220
                                                                                                       220
                                                               PC2/ADC2/PCINT10
                                                                              26
                                                               PC3/ADC3/PCINT11
                                                           PC4/ADC4/SDA/PCINT12
                                                                              28
                                                            PC5/ADC5/SCL/PCINT13
                                                              PC6/RESET/PCINT14
                                        ATMEGA328P
```

```
#define DT 10
const int firstLedPin = 3;
const int secondLedPin = 5;
const int thirdLedPin = 6;
void blinkLED(int pin, int duration)
     digitalWrite(pin, HIGH);
     delay(duration);
     digitalWrite(pin, LOW);
     delay(duration);
void setup()
     pinMode(firstLedPin, OUTPUT);
     pinMode(secondLedPin, OUTPUT);
     pinMode(thirdLedPin, OUTPUT);
void loop()
     blinkLED(firstLedPin, DT);
                                      U1
     blinkLED(secondLedPin, DT);
     blinkLED(thirdLedPin, DT);
                                        PD0/RXD/PCINT16
                                        PD1/TXD/PCINT17
                                        PD2/INT0/PCINT18
                          D1 ()
                                        PD3/INT1/OC2B/PCINT19
                                        PD4/T0/XCK/PCINT20
                          D2 O
                                       PD5/T1/OC0B/PCINT21
                                    12
                          D3 O
                                        PD6/AIN0/OC0A/PCINT22
                                    13
                                       PD7/AIN1/PCINT23
```

Connecting and Using LEDs

PB0/ICP1/CLKO/PCINT0

PB2/SS/OC1B/PCINT2

PB3/MOSI/OC2A/PCINT3

PB6/TOSC1/XTAL1/PCINT6

PB7/TOSC2/XTAL2/PCINT7

AREF

AVCC

ATMEGA328P

PB1/OC1A/PCINT1

PB4/MISO/PCINT4

PC0/ADC0/PCINT8

PC1/ADC1/PCINT9

PC2/ADC2/PCINT10

PC3/ADC3/PCINT11 PC4/ADC4/SDA/PCINT12

PC6/RESET/PCINT14

PC5/ADC5/SCL/PCINT13

PB5/SCK/PCINT5

15

16

17

18

19

9

10

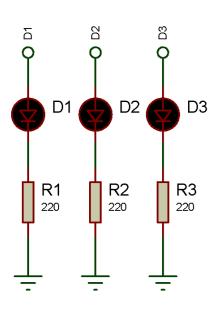
24

25

26

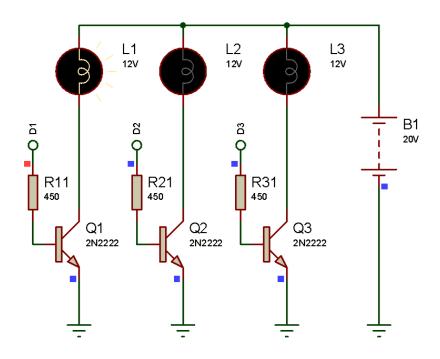
28

1



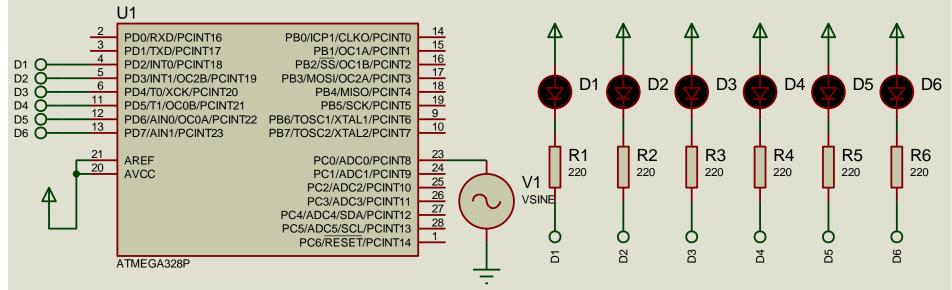
```
#define DT 100
const int firstLed = 3;
const int secondLed = 5;
const int thirdLed = 6;
Unsigned char brightness = 0;
int increment = 1:
void setup()
      // pins driven by analogWrite do not
      // need to be declared as outputs
void loop()
      if (brightness==255) increment*=-1;
      brightness+=increment;
      analogWrite(firstLed, brightness);
      analogWrite(secondLed, brightness);
      analogWrite(thirdLed, brightness);
      delay(DT);
                                                PB0/ICP1/CLKO/PCINTO
                             PD0/RXD/PCINT16
                             PD1/TXD/PCINT17
                                                   PB1/OC1A/PCINT1
                             PD2/INT0/PCINT18
                                                 PB2/SS/OC1B/PCINT2
                                                                =17
                             PD3/INT1/OC2B/PCINT19
                                                PB3/MOSI/OC2A/PCINT3
                                                    PB4/MISO/PCINT4
                             PD4/T0/XCK/PCINT20
                                                                =19
                             PD5/T1/OC0B/PCINT21
                                                    PB5/SCK/PCINT5
                                                                ■9
                             PD6/AIN0/OC0A/PCINT22
                                              PB6/TOSC1/XTAL1/PCINT6
                         13 ■
                                                                10
                             PD7/AIN1/PCINT23
                                              PB7/TOSC2/XTAL2/PCINT7
                             AREF
                                                   PC0/ADC0/PCINT8
                             AVCC
                                                   PC1/ADC1/PCINT9
                                                   PC2/ADC2/PCINT10
                                                                ■26
                                                   PC3/ADC3/PCINT11
                                                PC4/ADC4/SDA/PCINT12
                                                PC5/ADC5/SCL/PCINT13
                                                  PC6/RESET/PCINT14
                            ATMEGA 328P
```

Adjusting the Brightness of an LED



```
#define DT 10
                                       Adjusting the Color
const int redPin = 3;
const int greenPin = 5;
                                               of an LED
const int bluePin = 6;
int R = 255, G = 165, B = 0; // Orange
void setup()
     // pins driven by analogWrite
     // do not need to be declared as outputs
void loop()
     analogWrite(redPin, R);
     analogWrite(greenPin, G);
     analogWrite(bluePin, B);
     delay(DT);
                                             DIGITAL
                                                           220
                                                                220
                                                                       220
                                         Arduino
                                                          0hm
                                                                0hm
                                                                       0hm
      1 Red
      2 Ground
      4 Blue
```

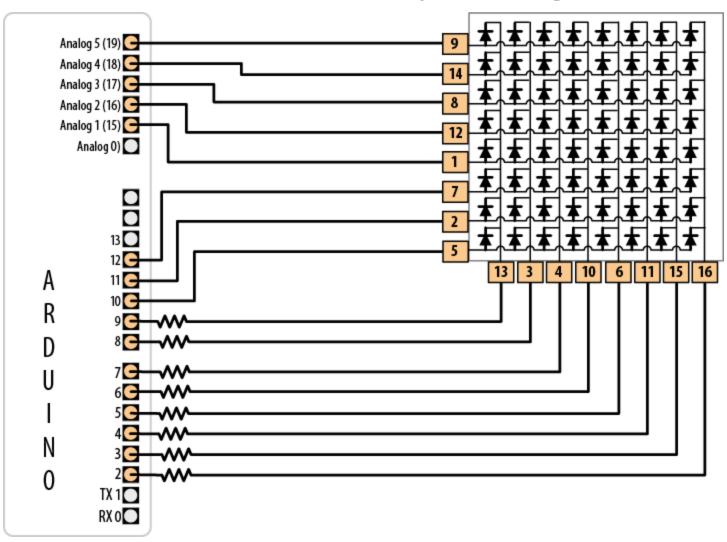
```
const int leds[] = { 2, 3, 4, 5, 6, 7};
                                             Sequencing Multiple
const int nLeds = sizeof(leds)/sizeof(int);
const int analogInPin = 0;
void setup() {
     for (int i = 0; i < nLeds; i++)</pre>
          pinMode(leds[i], OUTPUT);
void loop() {
     int sensorValue = analogRead(analogInPin);
     sensorValue = map(sensorValue, 0, 1023, 0, nLeds);
     for (int i = 0; i < nLeds; i++)</pre>
          if(i < sensorValue)</pre>
               digitalWrite(leds[i], HIGH);
          else
               digitalWrite(leds[i], LOW);
```

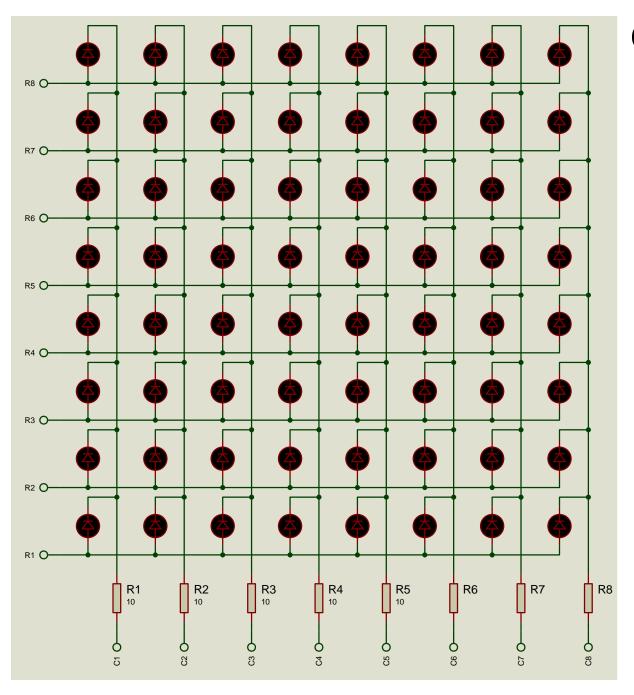


LEDs 1

```
#define DT 5
                                                          Sequencing Multiple
const int leds[] = { 2, 3, 4, 5, 6, 7};
const int nLeds = sizeof(leds)/sizeof(int);
const int analogInPin = 0;
                                                                           LEDs 2
void setup() {
      for (int i = 0; i < nLeds; i++)</pre>
           pinMode(leds[i], OUTPUT);
void loop() {
      for (int i = 0; i < nLeds-1; i++)</pre>
           digitalWrite(leds[i], HIGH); delay(DT);
           digitalWrite(leds[i+1], HIGH); delay(DT);
           digitalWrite(leds[i], LOW); delay(DT*2);
      for (int i = nLeds; i > 0; i--) {
           digitalWrite(leds[i], HIGH); delay(DT);
           digitalWrite(leds[i-1], HIGH); delay(DT);
           digitalWrite(leds[i], LOW); delay(DT*2);
              U1
               PD0/RXD/PCINT16
                                    PB0/ICP1/CLKO/PCINT0
                                                        15
               PD1/TXD/PCINT17
                                        PB1/OC1A/PCINT1
                                                       16
 D1 (
               PD2/INT0/PCINT18
                                     PB2/SS/OC1B/PCINT2
                                                        17
 D2 C
               PD3/INT1/OC2B/PCINT19
                                    PB3/MOSI/OC2A/PCINT3
                                                                           D2
                                                                                    D3
                                                                                                      D5
                                                                                                               D<sub>6</sub>
                                                                                             D4
           6
 D3 C
               PD4/T0/XCK/PCINT20
                                        PB4/MISO/PCINT4
                                                       19
           11
 D4 (
               PD5/T1/OC0B/PCINT21
                                         PB5/SCK/PCINT5
           12
 D5 C
                                  PB6/TOSC1/XTAL1/PCINT6
               PD6/AIN0/OC0A/PCINT22
           13
                                                       10
 D6 (
               PD7/AIN1/PCINT23
                                  PB7/TOSC2/XTAL2/PCINT7
                                                                 R1
                                                                          R2
                                                                                  R3
                                                                                                             R6
                                                        23
                                                                                           R4
                                                                                                    R5
               ARFF
                                        PC0/ADC0/PCINT8
                                                       24
                                                                220
                                                                         220
                                                                                  220
                                                                                           220
                                                                                                    220
                                                                                                             220
               AVCC
                                        PC1/ADC1/PCINT9
                                                       25
                                       PC2/ADC2/PCINT10
                                                       26
                                       PC3/ADC3/PCINT11
                                                        27
                                    PC4/ADC4/SDA/PCINT12
                                    PC5/ADC5/SCL/PCINT13
                                      PC6/RESET/PCINT14
              ATMEGA328P
```

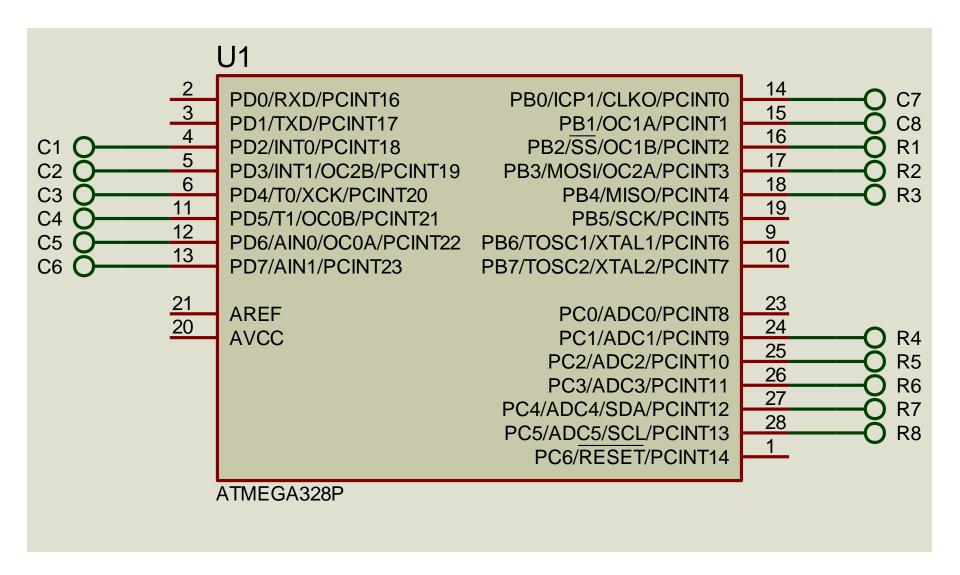
Controlling a LED Matrix Using Multiplexing





Controlling a LED Matrix Using Multiplexing

Controlling an LED Matrix Using Multiplexing

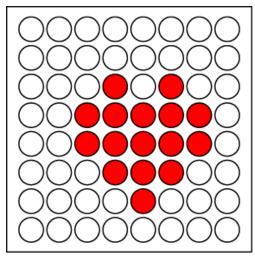


Controlling an LED Matrix Using Multiplexing

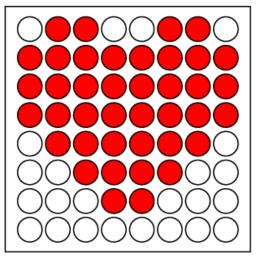
```
#define DT 10
const int columnPins[] = { 2, 3, 4, 5, 6, 7, 8, 9};
const int rowPins[] = { 10,11,12,15,16,17,18,19};
int iRow = 0:
int iColumn = 0;
void setup() {
     for (int i = 0; i < 8; i++) {
          pinMode(columnPins[i], OUTPUT);
          pinMode(rowPins[i], OUTPUT);
void loop() {
    for(int c = 0; c < 8; c++)
      digitalWrite(columnPins[c], (c==iColumn)?LOW:HIGH);
     for (int r = 0; r < 8; r++)
      digitalWrite(rowPins[r], (r==iRow)?HIGH:LOW);
     delay(DT);
     iColumn++;
     if (iColumn==8) {iColumn = 0; iRow++;}
     if(iRow==8) \{iColumn = 0; iRow = 0; \}
}
```

```
#define DT 50
byte bigHeart[] = { B01100110, B11111111, B11111111, B11111111,
                    B01111110, B00111100, B00011000, B00000000);
byte smallHeart[]={ B00000000, B00000000, B00010100, B00111110,
                    B00111110, B00011100, B00001000, B00000000);
const int columnPins[] = { 2, 3, 4, 5, 6, 7, 8, 9};
const int rowPins[] = { 10,11,12,15,16,17,18,19};
void show( byte * image, unsigned long duration) {
     unsigned long start = millis();
     while (start + duration > millis()){
          for (int row = 0; row < 8; row++) {
               digitalWrite(rowPins[row], HIGH);
               for(int column = 0; column < 8; column++){</pre>
                    boolean pixel = bitRead(image[row],column);
                    if (pixel) digitalWrite (columnPins[column], LOW);
                    delayMicroseconds (300);
                    digitalWrite(columnPins[column], HIGH);
               digitalWrite(rowPins[row], LOW);
     }
void setup() {
     for (int i = 0; i < 8; i++) {
          pinMode(rowPins[i], OUTPUT)
          pinMode(columnPins[i], OUTPUT);
          digitalWrite(columnPins[i], HIGH);
void loop() {
     show(smallHeart, DT);
     show(bigHeart, 2*DT);
     delay(5*DT);
```

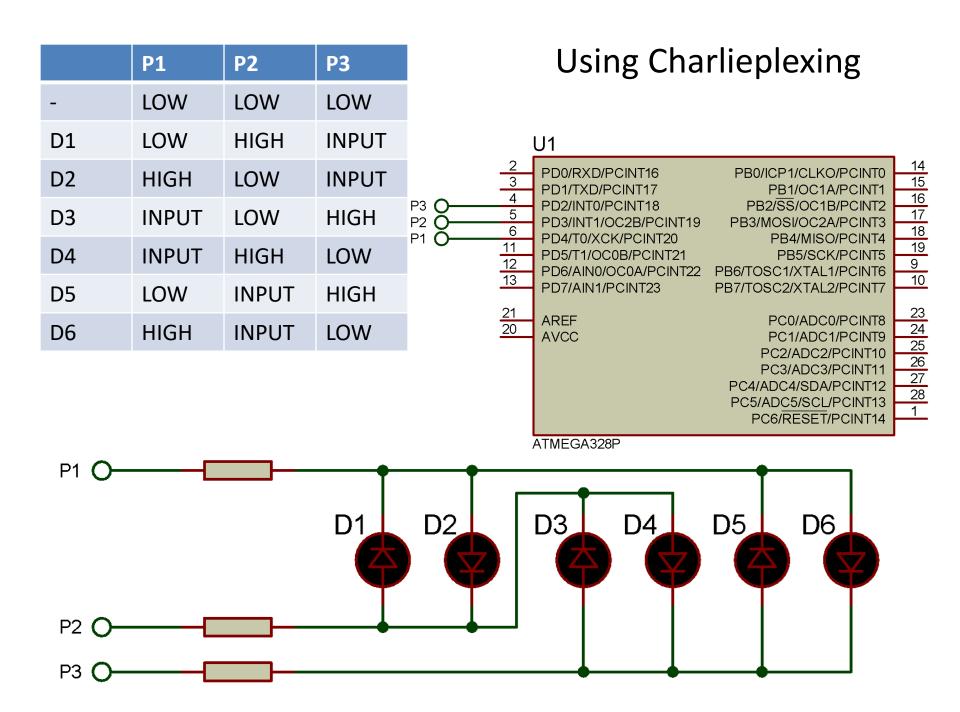
Showing Images



Small Heart



Big Heart

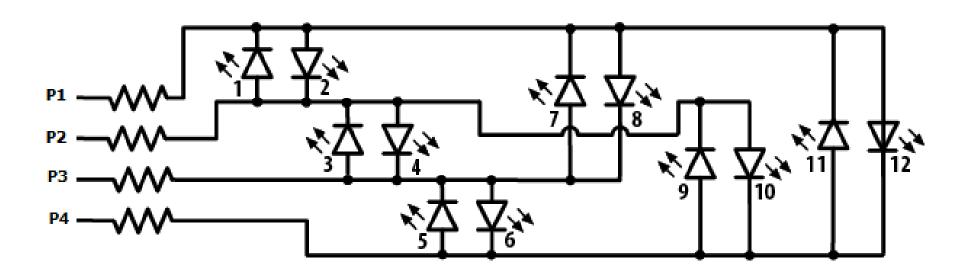


```
#define DT 100
byte pins[] = \{2,3,4\};
const int NUMBER OF PINS = sizeof(pins) / sizeof(pins[0]);
const int NUMBER OF LEDS = NUMBER OF PINS * (NUMBER OF PINS-1);
byte pairs [NUMBER OF LEDS/2][2] = { \{0,1\}, \{1,2\}, \{0,2\} \};
void setup(){}
void loop(){
     for(int i=0; i < NUMBER OF LEDS; i++) {</pre>
          lightLed(i);
          delay(DT);
void lightLed(int led) {
     int indexA = pairs[led/2][0];
     int indexB = pairs[led/2][1];
     int pinA = pins[indexA];
     int pinB = pins[indexB];
     for(int i=0; i < NUMBER OF PINS; i++) {</pre>
          if(i!=indexA && i!=indexB){
               pinMode(pins[i], INPUT);
                digitalWrite(pins[i],LOW);
     }
     pinMode(pinA, OUTPUT);
     pinMode(pinB, OUTPUT);
     if( led % 2 == 0) {
          digitalWrite(pinA,LOW);
          digitalWrite(pinB,HIGH);
     }
     else{
          digitalWrite(pinB,LOW);
          digitalWrite(pinA, HIGH);
```

}

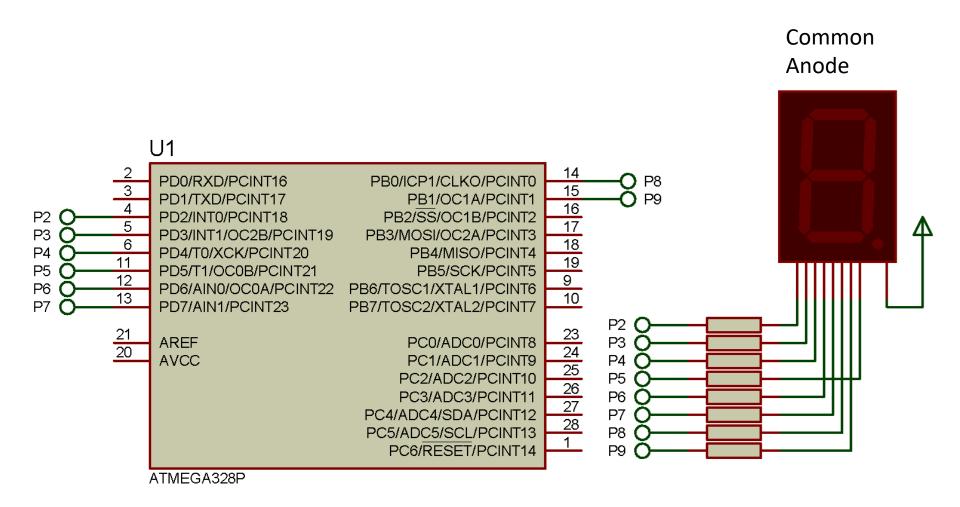
Using Charlieplexing

Using Charlieplexing



	P1	P2	Р3	P4
-	LOW	LOW	LOW	LOW
D1	LOW	HIGH	INPUT	INPUT
D2	HIGH	LOW	INPUT	INPUT
D3	INPUT	LOW	HIGH	INPUT
D4	?	?	?	?

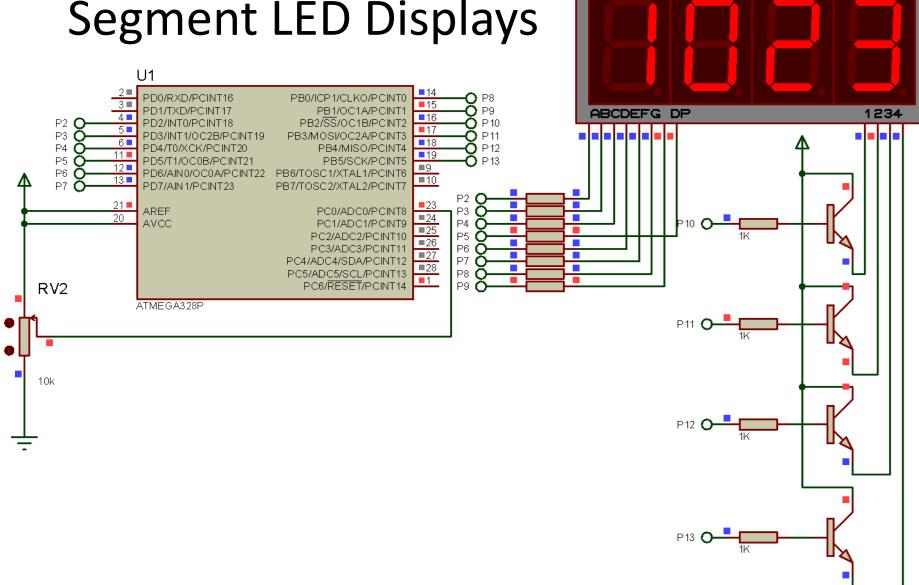
Driving a 7-Segment LED Display



```
#define DT 50
const byte digits[10] = {
   //ABCDEFGP
     B11111100, // 0
     B01100000, // 1
     B11011010, // 2
     B11110010, // 3
     B01100110, // 4
     B10110110, // 5
     B00111110, // 6
     B11100000, // 7
     B11111110, // 8
     B11100110, // 9
};
const int segmentPins[8] = { 5,9,8,7,6,4,3,2};
int number= 0;
void setup(){
     for(int i=0; i < 8; i++)</pre>
          pinMode(segmentPins[i], OUTPUT);
void loop(){
     showDigit(number++);
     delay(DT);
     if (number==10) number= 0;
void showDigit(int number) {
     for(int segment = 0; segment < 8; segment++)</pre>
          boolean isBitSet = bitRead(digits[number], segment);
          digitalWrite( segmentPins[segment], !isBitSet);
}
```

Driving a 7-Segment LED Display

Driving Multidigit 7-Segment LED Displays



```
#define DT 1
const byte digits[10]={ B11111100, B01100000, B11011010,
                             B11110010, B01100110, B10110110,
                             B00111110, B11100000, B11111110,
                             B11100110};
const int segmentPins[8] = \{5,9,8,7,6,4,3,2\};
const int digitPins[4] = {10,11,12,13};
                                                Driving Multidigit
int nDigits = sizeof(digitPins)/sizeof(int);
void setup(){
     for(int i=0; i < 8; i++)</pre>
                                                  7-Segment LED
         pinMode(segmentPins[i], OUTPUT);
     for(int i=0; i < nDigits; i++)</pre>
         pinMode(digitPins[i], OUTPUT);
                                                          Displays
void loop(){
     int value = analogRead(0);
     showNumber(value);
void showNumber(int number) {
     for(int digit = nDigits-1; digit >= 0; digit--){
          showDigit(number % 10, digit) ;
          number = number / 10;
void showDigit(int number, int digit) {
     digitalWrite(digitPins[digit], HIGH);
     for(int segment = 0; segment < 8; segment++)</pre>
         boolean isBitSet = bitRead(digits[number], segment);
         digitalWrite( segmentPins[segment], !isBitSet);
     delay(DT);
     digitalWrite(digitPins[digit], LOW);
```