Display

CSE 132

Upcoming Logistics

- Full hardware kits needed today – LCD display
  - One per group OK for studio
  - Purchase in department office
- Quiz 2 – available this afternoon, due Wed.
  - Change: two dropped quizzes during the semester
- Midterm exam – Thur., March 3, 6:30-8:30pm
  - Lab Sciences 300, NOT HERE!!!!!!!!!!!
  - We will start right at 6:30, NOT 6:40!
  - Let me know about conflicts in quiz
  - Review in lecture and studio next week, help session next Tue evening (Lopata 101, 8-10pm)

Two Assignment 4 Issues

- Typo in cover-page.txt
  - 0x21 0x35 0x94 0x30 0x10 0x11
- Sending 4-byte floats isn't easy, use this:

```
float f = 23.5;
unsigned long rawBits;

rawBits = *(unsigned long *) &f;
```

Today's Outline

- LCD display – initialization and use
- I2C peripheral devices – including LCD display
- Information representation – images

LCD Display on Arduino

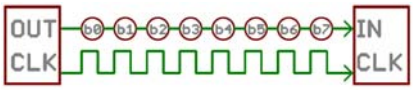
- 2x16 character LCD display (class ST7036)
  - print() method is available
    - Accepts multiple data types: string, int, etc.
- Initialization and use
  - Constructor: `ST7036 lcd = ST7036(2,16,0x7c);`
  - In setup(): `lcd.init();`
    `lcd.setContrast(0);`
  - In loop():

```
lcd.setCursor(line, column);
lcd.print("Hi!");
```

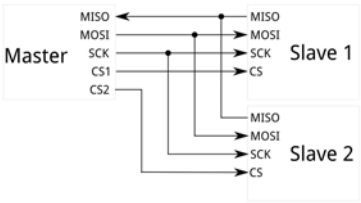
Serial Communications

- UART – universal asynchronous receiver/transmitter

Synchronous Interface



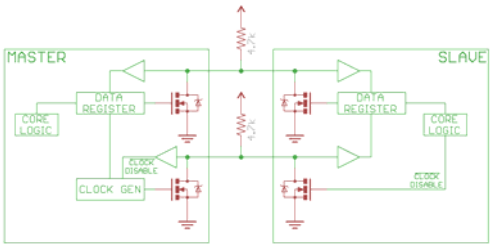
- SPI – serial peripheral interface



Supporting Multiple Masters

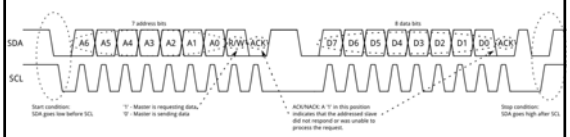
- I^2C – inter-integrated circuit bus

Physical Hardware



Bit-level Communication

- Protocol
  - Address bits first – msb to lsb (7 bits)
  - R/W indicator – (1 bit)
  - Ack / Nack – (1 bit)
  - Data bits last – msb to lsb (8 bits)



Images

- Consider the following bits:

0x002400081881423c

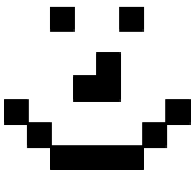
0000 0000 0010 0100 0000 0000 0000 1000

0001 1000 1000 0001 0100 0010 0011 1100

- Make 1 dark and 0 light:

Images

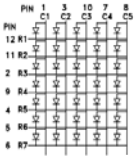
- Arrange in rows, one byte per row:



- Each bit is a “pixel” in the image

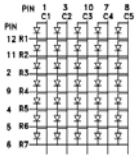
Controlling pixels

- Common approach is row, column multiplexing



- Extend with intensity control for each pixel
  - 8 bits → 0 is "off", 255 (or 0xff) is "on"

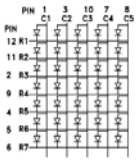
Row-based Multiplexed Control




```
for r = 1 to 7
    wait until next row time
    set row_r LOW
    set all other rows HIGH
    for c = 1 to 5
        set column_c to value for row_r
        (HIGH for on, LOW for off)
    end for
end for
```

This needs series resistors on each column

Column-based Multiplexed Control




```
for c = 1 to 5
    wait until next column time
    set column_c HIGH
    set all other columns LOW
    for r = 1 to 7
        set row_r to value for column_c
        (LOW for on, HIGH for off)
    end for
end for
```

This needs series resistors on each row

Add color and more pixels

Color

- Additive color – primaries Red, Green, Blue

- Position close together and put diffuser above
  - This builds one pixel