Last Time

• Finite State Machines
• 3-bit Digital to Analog (D2A) Converter
Today

- Finish D2A
- Analog to Digital (A2D) conversion

Back today:
- HW4, Group quiz

Due today: project 4
Next Time

• Discussion of HW 4 and group quiz
• Exam preparation

• Submit suggested exam questions and answers to the D2L discussion group
Digital to Analog and Back

• Analog: encoding information using voltage
  – Many sensors use voltage as an output
  – Motors torque is determined by current passing through the motor

• Digital: encoding information with bits

How to move between these?
Digital to Analog Conversion

On the group quiz: 3-bit D2A converter
• Process specifies a digital output
• Within a short period of time (~ 1 ns), the voltage settles to the value that we computed
Analog to Digital Conversion

For a given voltage, what is the digital representation of the voltage?

• How would we implement this?
Analog to Digital Conversion

- For a given voltage, what is the digital representation of the voltage?

- Common approach: successive approximation
  - Use a D2A converter to produce a voltage \( V \)
  - Compare this with the input voltage \( V_i \)
  - If different, then increase/decrease \( V \)
  - Repeat (stopping when \( V \) is close to \( V_i \))
A2D in the Mega8

- The mega8 contains hardware that implements successive approximation
- 6 mega8 pins can be configured as analog input pins
A2D in the Mega8

AVCC: connect to +5V

AREF: (optional) connect to +5V

- Measuring voltages between 0 and +5V

Connect input analog signal to the appropriate ADC pin
A Code Example

// Initialize adc
adc_set_reference(ADC_REF_AREF);       // Use the AREF reference pin
adc_set_adlar(0);                      // For our purposes, always use 0
adc_set_prescalar(ADC_PRESCALAR_128);  // Necessary with 16MHz clock
// and 10 bit resolution

// Turn on ADC Converter
adc_set_enable(ADC_ENABLE);

: :

long val;

// Can do the following an arbitrary number of times

adc_set_channel(ADC_CHANNEL_0);        // ADC0
// Actually start a conversion
adc_start_conversion();

<Could go off and do something else for a while>

val = adc_read(); // Read the analog value
Analog Conversion Notes

• All functions are provided in oulib
• See oulib.h for the definition of constants

• Can get to the example code from the Atmel HowTo
  www.cs.ou.edu/~fagg/classes/general/atmel
Analog Conversion Notes

• Setting the maximum voltage:

```c
adc_set_reference(ADC_REF_AREF);       // Use the AREF reference pin
```

• Can also used a fixed voltage (+2.56V):

```c
adc_set_reference(ADC_REF_2p56V);
```
Analog Conversion Notes

• Determining how fast the conversion requires:

```c
adc_set_prescalar(ADC_PRESCALAR_128);  // Necessary with 16MHz clock
// and 10 bit resolution
```

• Conversion requires:

128 * 15 / 16000000  seconds
– Can convert faster, but may not get the full 10-bit resolution
Analog Conversion Notes

• Reading out the value:

    val = adc_read(); // Read the analog value

• Blocks until conversion is complete
• Will return a value between 0 and 0x3FF (1023)
Analog Conversion Notes

• Can configure the mega8 to interrupt on conversion completion
Other Devices

• External devices are available that will perform D2A and A2D

• Often interface to the microprocessor via I²C or SPI
  – (these are high-speed serial protocols)

• Many options
  – Resolution
  – Conversion speed
  – Number of channels