

# uC Crash Course

Joshua Childs  
Joshua Hartman  
A. A. Arroyo

## Whats is covered in this lecture

- ESD
- Choosing A Processor
- GPIO
- USARTS
  - RS232
  - SPI
- Timers
  - Prescalers
  - OCR
  - ICR
  - PWM
- ADC
- Interrupts

## ESD KILLS!

- Always be cautious of ESD warnings
- Some chips are more sensitive than others
- Use an ESD strap and mat
- If none are available touch a large grounded object

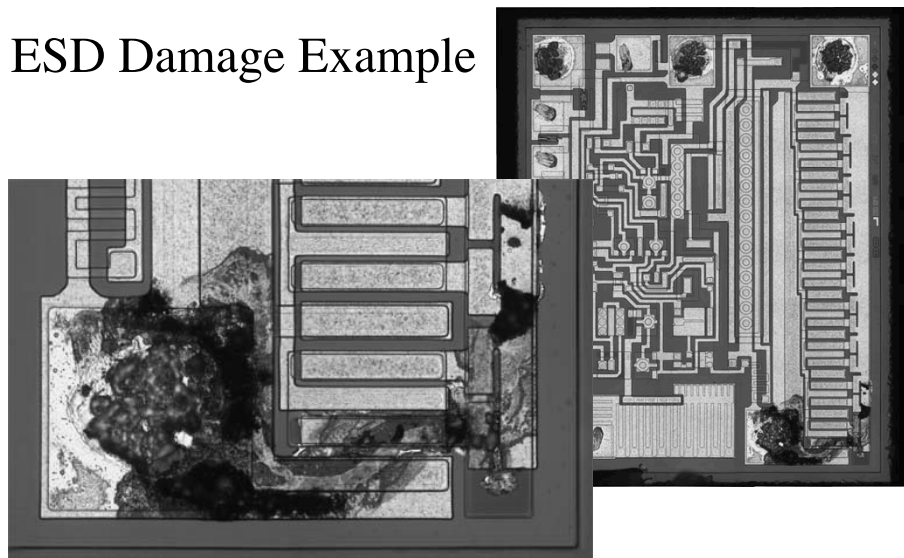


Pictures:

[commons.wikimedia.org](http://commons.wikimedia.org)  
[www.ultrastatic.com](http://www.ultrastatic.com)

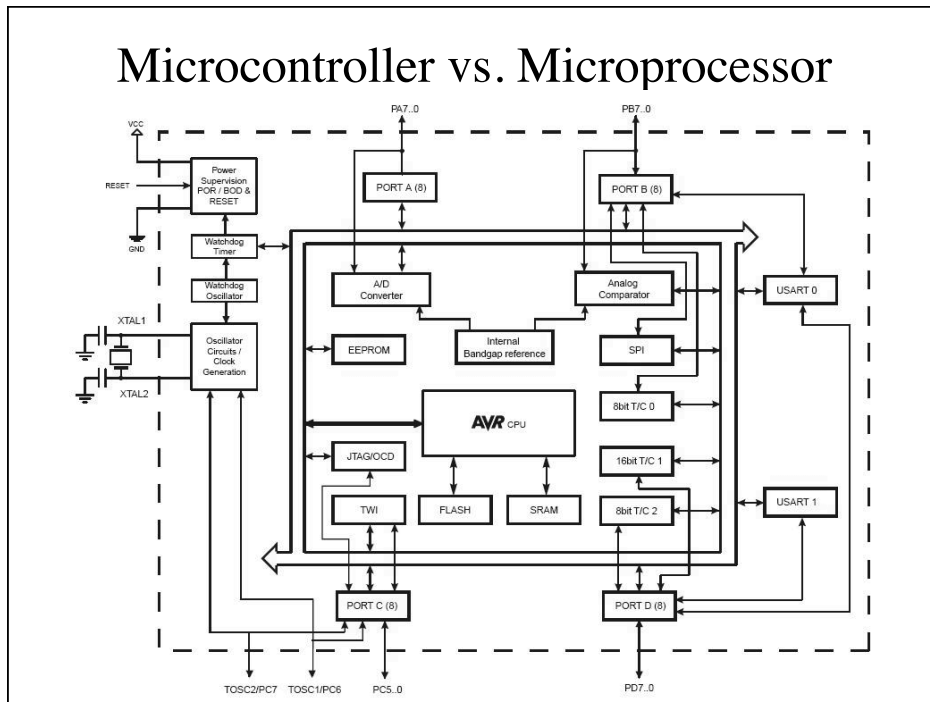


## ESD Damage Example



[bunniestudios.com/blog/images/ams1117\\_esd\\_lg.jpg](http://bunniestudios.com/blog/images/ams1117_esd_lg.jpg)

## Microcontroller vs. Microprocessor



## Choosing a Microcontroller

- External connections
  - GPIO
  - ADC
  - USARTS
- Processing Power
  - is 8 bits enough?
- Chip size
  - DIP or surface mount
- Electrical Power
  - This is based on the power source

## Choosing a Microcontroller

### AVR - Atmel

- Popular processor
- Lots of support at uf
- AVR Studio
- Programmer ~\$17 (University Program)

### Microchip - PIC

- Comparable to Atmel
- Can be programed in Basic
- Free Samples
- Programmer ~\$35

### TI -MSP 430

- Low power
- Steeper learning curve
- Free Samples
- Programmer ~\$50 (University Program)

## Choosing a Microprocessor

### Propeller

- Multicore processor
- Prebuilt functions for audio and video

### Freescale - Coldfire

- 32 bit processor
- Steep Learning Curve

### Freescale - ARM

- 32 bit processor
- Steep Learning Curve

### NIOS

- Softcore processor
- Contained in Altera FPGA
- Custom Opcodes

## Choosing a clock speed

Determine your processing power

- Special timing requirements
  - USART
    - Consult table in datasheet
  - Real Time clock
- Do you need a external crystal?
  - Atmel needs an external crystal for more then 8 Mhz

## Choosing a chip package

- Don't Fear Surfacemounts
  - See the TA's or Mike for soldering help
- DIP package
  - Can be used on protoboard
  - Excessively large package
- Surface Mount
  - Space efficient
  - requires PCB
- BGA
  - balls on bottem of package
  - harder to install

## GPIO

- Ports are typically 8bits mapped to one memory address
- Atmel
  - Use DDRx to set data direction
    - 0 is input
    - 1 is output
    - PIC is reversed
  - Use PORTx to write a port
  - Use PORTx to enable pull up
  - Use PINx to read a port
- Low source/sink current
  - External device may be used for high current

## Atmel Timer/Counters

What is a timer/counter?

- It's a timer that counts based on the system clock
- Can be used to toggle a pin (you saw this in the homework)
- Can be used to perform some activity based on time delay
- Can generate a PWM (square wave) signal. PWM is great for driving motors.

Atmega32 features:

- 8 bit timer/counter 0
- 16 bit timer/counter 1
- 8 bit timer/counter 2

## Timer/Counter 0 Registers

TCNT0 - The running clock

OCR0 - Output compare register (things usually happen when OCR0 = TCNT0). Also used for PWM

TCCR0 - Used to "setup" the timer/counter.

- Sets the timer speed
- Sets up the PWM mode
- Sets up Output compare

TIMSK - The timer interrupt register. Enables overflow interrupts and output compare interrupts

TIFR - Timer flag register. Bits will be set upon overflow or output compare

## Setting the timer/counter speed

Bits CS02:CS00 (clock select) in TCCR0

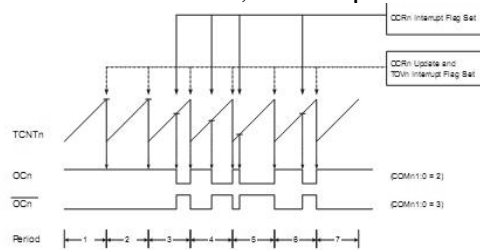
CS02	CS01	CS00	Description
0	0	0	No clock source (Timer/Counter stopped).
0	0	1	$clk_{I/O}$ / (No prescaling)
0	1	0	$clk_{I/O}$ / 8 (From prescaler)
0	1	1	$clk_{I/O}$ / 64 (From prescaler)
1	0	0	$clk_{I/O}$ / 256 (From prescaler)
1	0	1	$clk_{I/O}$ / 1024 (From prescaler)
1	1	0	External clock source on T0 pin. Clock on falling edge.
1	1	1	External clock source on T0 pin. Clock on rising edge.

## PWM Modes

**Normal Mode:** Counter goes from 0 to TOP (255 for 8-bit timers).  
Not super useful, but could be used for exact timing, or long-term timing.

**CTC Mode:** Useful for generating very exact waveforms.

**Fast PWM:** Counts from 0 to TOP and then back to 0  
When  $TCNT = OCR$ , the OC pin is cleared  
When  $TCNT = BOT$ , the OC pin is set



Confusing to use!

## Phase Correct PWM

- The best PWM mode - great for motors
- Counts from BOT to TOP then back down to BOT
- On OC match, pin is either cleared or set
- For motors, you probably want a frequency of around 10kHz
- For 75% power, just set OCR to be  $.75 * TOP$

Initialization Code:

```
TCCR0 = _BV(WGM01) | _WGM(00); //sets up phase-correct PWM
TCCR0 |= _BV(COM01); //clear on up-count, set on down
TCCR0 |= _BV(CS00); //CLK = System clock/1
```

Using Code:

```
OCR0 = (uint8_t) (desiredSpeed * 0xFF);
```

## ADC

An analog to digital converter is used to sample and digitize analog signals.

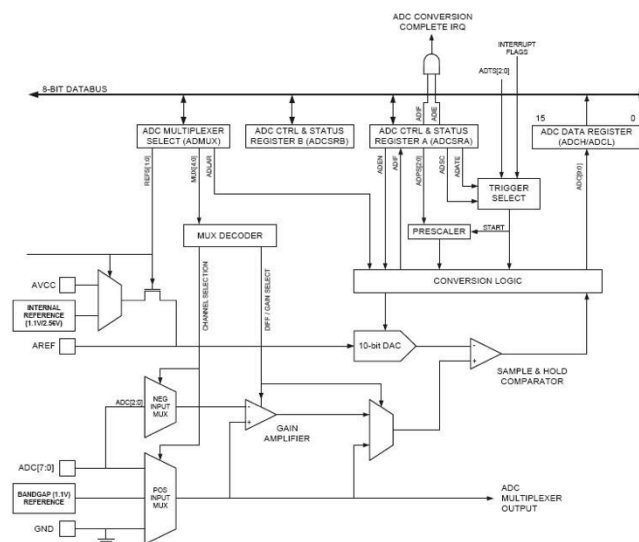
Typical Applications:

- Audio Input
- Checking battery voltage
- Sensor- ie. IR range finder

These devices can be very simple to communicate with and are usually quicker to set up than a serial device

Converts a 0-5V voltage level into a 10-bit range (0 to 1023). You can divide things into  $\sim 1\%$  increments

## ADC Diagram



## ADC Registers

### ADCSRA:

ADEN	Enables ADC
ADSC	Starts conversion(s)
ADIF	Conversion complete (an interrupt flag)
ADPS2:0	Divides the clock (like in the timer example)

ADMUX: A big multiplexer. Tells you which pin you want to do a conversion on. Also lets you select voltage reference.

## ADC Gotchas

Frequency must be between 50kHz - 200kHz for full resolution  
13 Clock cycles needed for a conversion (successive approximation)  
First conversion actually needs 25 clock cycles. Good idea to throw away the first few.

## USART

### RS-232 Communication

- Async or Sync operation
- 5,6,7,8 or 9 data bits
- 1 or 2 stop bits
- Even, Odd or No Parity
- TTL Logic Levels
- Interrupts or polling of status registers

## USART

### SPI Communication

- Synchronous serial
- Requires 3 wires plus an enable
- Easy to connect multiple devices
- Master Operation
- 4 Modes of operation
- LSB or MSB
- High Speed

## Interrupts

TA Rule of thumb: Don't use them if you can get away with it.

Interrupts make things happen "out of order". Usually you can get by with polling a device every so often and updating a value. I know polling seems like a "dumb way" of doing things. It's not.

If you really want to use them, keep the code as short as possible.

Useful for:

- Triggering that an ADC conversion is complete
- Having an event happen on intervals based on the clock
- External Interrupts: Do something when a pin changes. This is great if you have critical data to process
- Can tell you when tasks finish

I built a segway and a robot. Neither use a single interrupt.

## Debugging Tips

- Have a feedback system to verify program operation
  - LCD Screen
  - LED Bank
  - Serial Output to PC
- Use the Proper test equipment
  - DMM
    - Testing static signals and supply voltages
    - Will average AC signals
  - Scope
    - Verify signals
    - Look for noise
  - LSA
    - Verify logic levels of data
    - Multiple inputs

## Useful Websites

AVR-LIBC: Detailed descriptions of library files. Really useful!  
<http://www.gnu.org/savannah-checkouts/non-gnu/avr-libc/user-manual/modules.html>

AVRFREAKS: Smart robot guys with an amazing forum. Will solve all your problems  
<http://www.avrfreaks.net>

The datasheet. Google for it. Read it. Then ask questions.