

# Microcontroller Basics

Gabe Cohn

CSE 599U – February 8, 2010

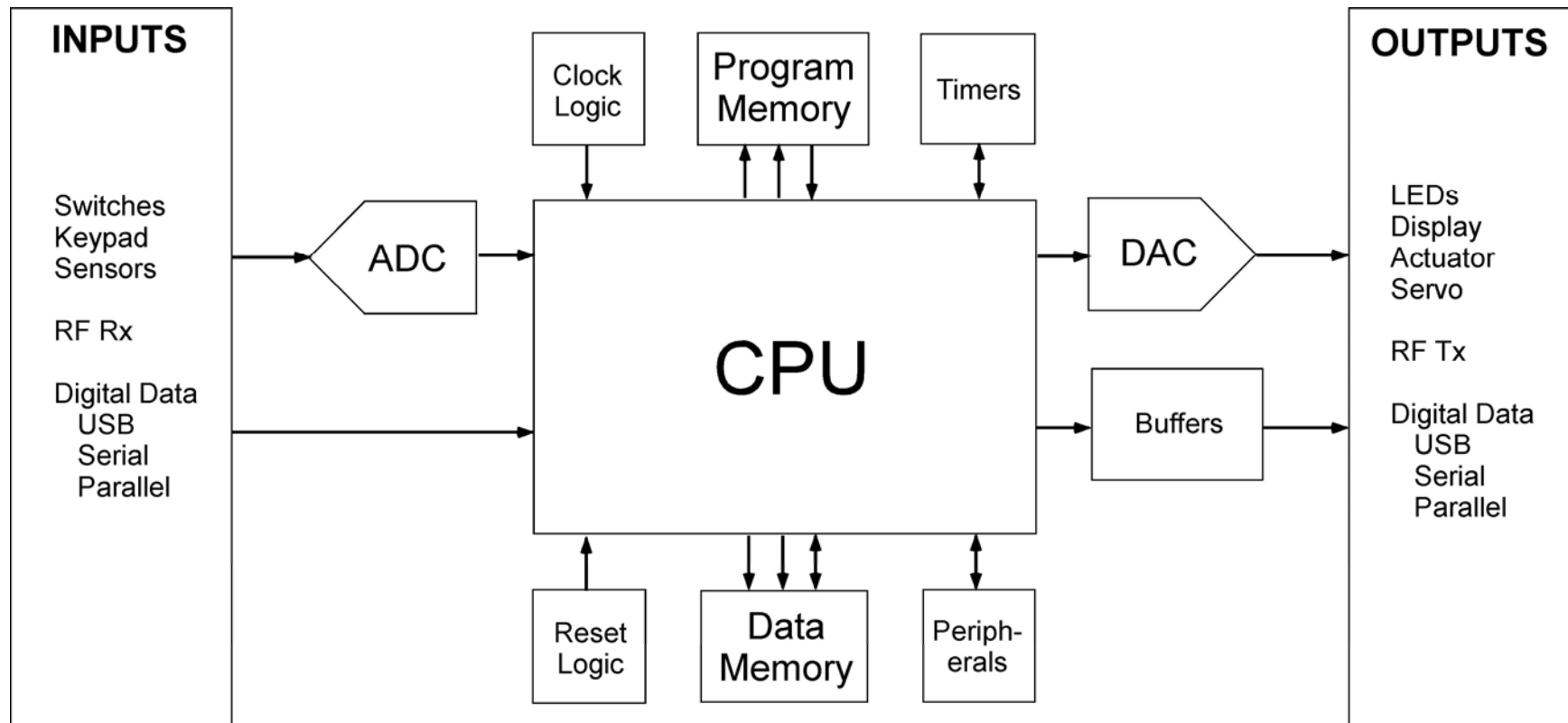
# Outline

- Overview of Embedded Systems
- What is a Microcontroller?
- Microcontroller Features
- Common Microcontrollers
- Choosing a Microcontroller
- Development Kits

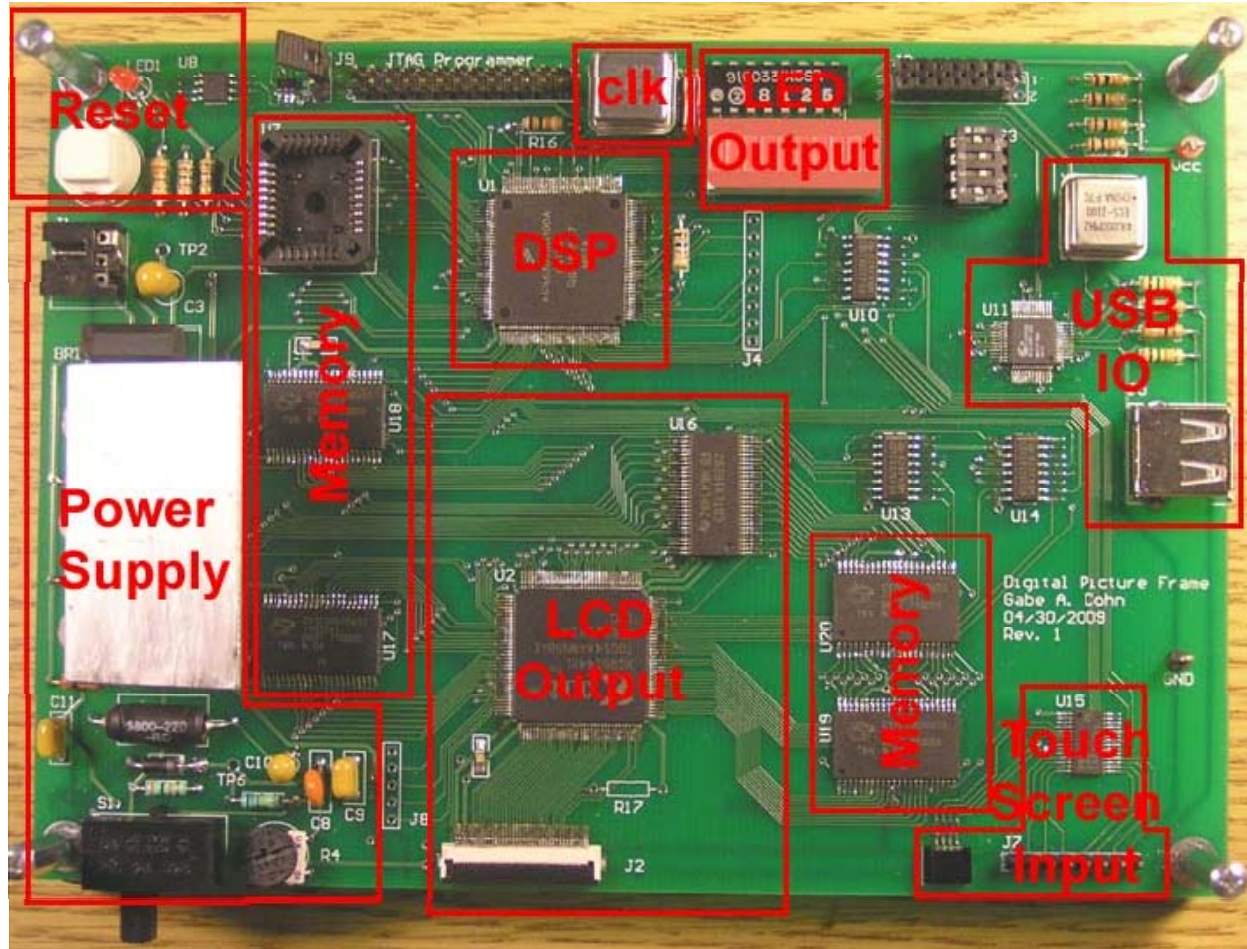
# Overview of Embedded Systems

- Minimal computation, simple software (no/simple OS)
- Low power (typically battery powered)
- Event Driven Design
- Mostly IO (Inputs and Outputs)
  - Sensors, Switches, Keypad
  - Displays, LEDs
  - Actuators, Servos
  - Data communication (wired or wireless)
- Data Conversion
  - Analog-to-Digital, Digital-to-Analog

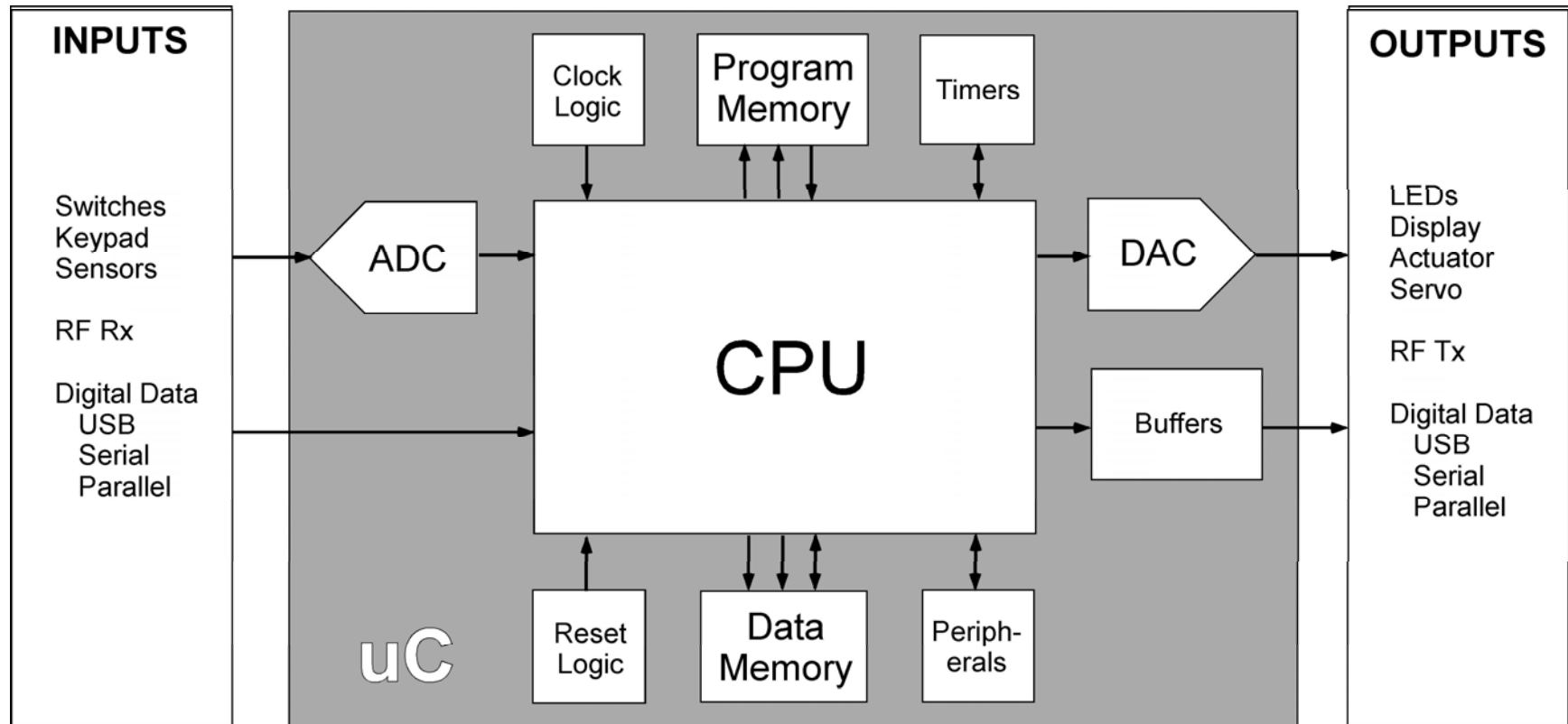
# Generic Embedded Systems



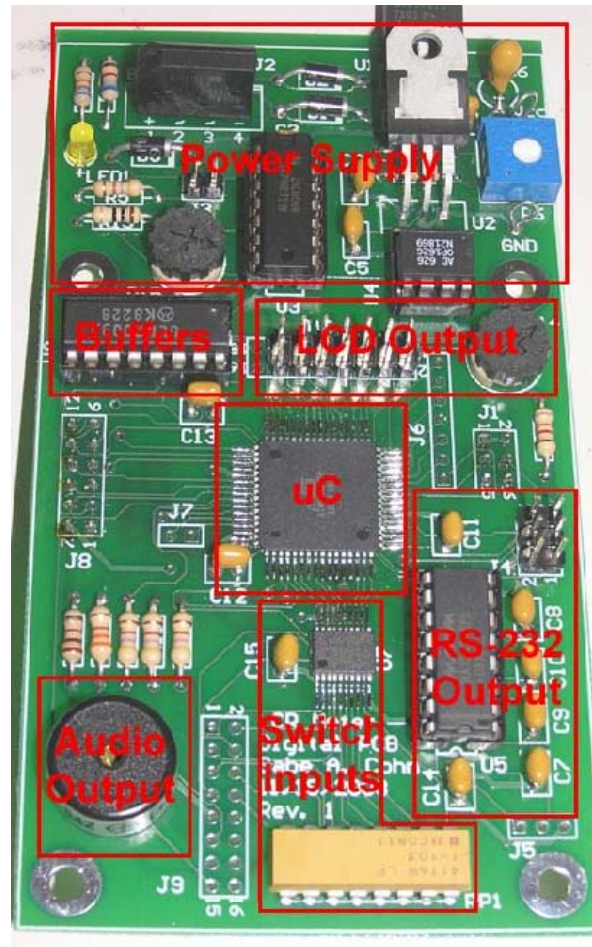
# Example: Using Discrete Components



# What is a Microcontroller?



# Example: Using A Microcontroller



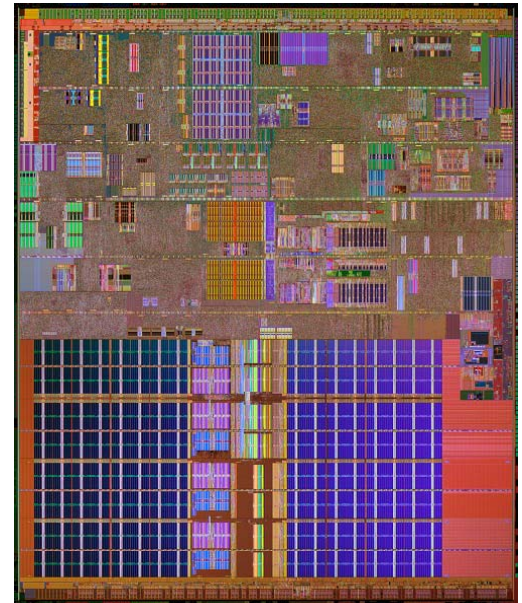
# Microcontroller Features

- CPU
- Program and Data Memory (ROM and RAM)
- Reset and Oscillator Circuitry
- Timers
- Data Converters (ADC, DAC)
- Buffered GPIOs
- Simple Peripheral Interface
- Reduced System Size, Complexity and Cost



# CPU

- RISC
- Harvard Architecture (separate program and data memory)
- Pipelined Load-Store Architecture
- Lower clock speeds (8-32 MHz)
- Optimized for low-level compilers like C
- Typically no OS is used (sometimes RTOS)



# Memory

- On-chip RAM and ROM
- No external access to address and data buses
- Need a “programmer” to program the code into the ROM (typically Flash these days)
- Size range 10s of bytes to 100s of KB
  - main difference in price between similar products



# Reset and Oscillator Circuitry

- Reset
  - Internal or External
  - Watchdog Timer (WDT)
  - Brownout Reset (BOR)
- Oscillator
  - Several sources to choose from
  - Internal or External
  - PLL and clock frequency adjustment

# Timers

- Typically several different timers
  - Real-Time Clock (RTC)
  - Watchdog Timer (WDT)
  - PWM output common
- Several clocking options
- Event based notification (Interrupts)
  - Allows CPU to focus on foreground tasks

# Data Converters

- ADC (very common)
  - Several channels
  - Multiple clocking options
  - Several different types
  - Comparators and other analog circuitry
  - Important for ratiometric sensors
- DAC (less common)
  - Several different types

# GPIOs

- Many General Purpose Analog/Digital IOs
  - Buffered to drive typical embedded loads
  - Multiplexed for several functions
  - Switchable internal pull-up, latch, etc...
  - Edge detection
  - Schmitt trigger inputs on some
  - main difference in price between similar products

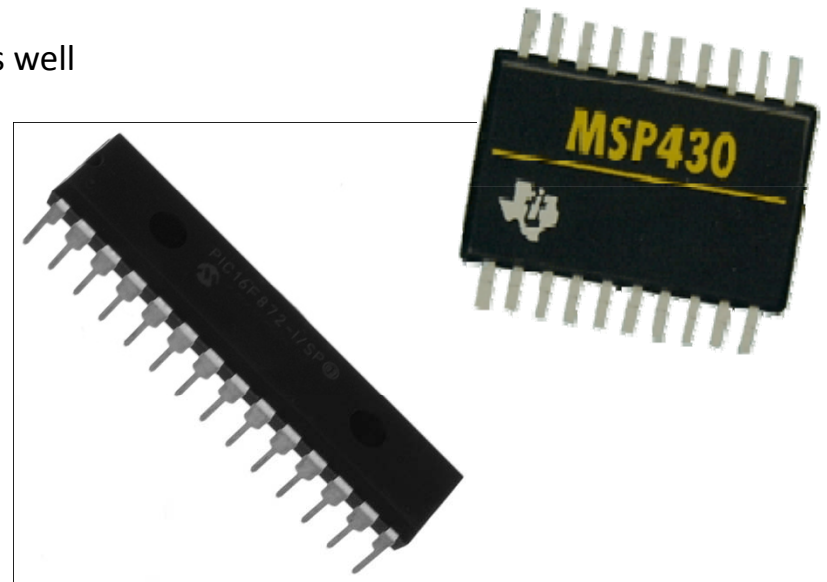
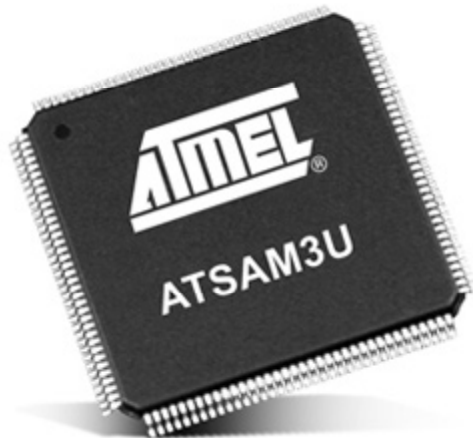
# Simple Peripheral Interface

- Serial (Sync/Async, SPI, I<sup>2</sup>C)
- CAN bus (automotive)
- LED and LCD controllers
- Ethernet, USB, and Video controllers
- DMA, DRAM, SDRAM controllers
- Host Processor Interface, External Memory Bus

# Common Microcontrollers

Family	Manufacturer	Word Size*	Common Uses
ARM	Various	32-bit	Consumer Electronics
AVR	Atmel	8-bit	
PIC	Microchip	8-bit	Hobbyist
MSP430	TI	16-bit	Low Power
6805	Motorola/Freescale	8-bit	Automotive

\* Many of these  $\mu$ Cs now come in wider bus architectures as well



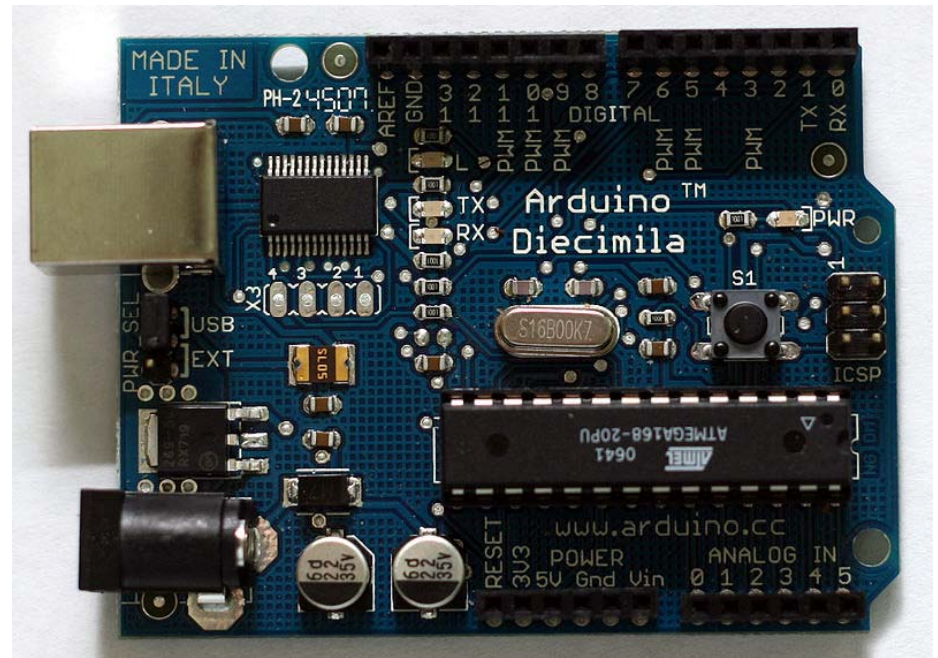


# Choosing a Microcontroller

- All very similar, so stick with a family you know
- Required features
- Required number of GPIOs
- Memory requirements
- Availability of programmer (USB?)
- Availability of a good C compiler
- Packaging

# Development Kits

- Fast and Easy!
- Everything you need is included
  - uC, power supply, USB connection, simple IO
- Low level code is written for you!
  - `port_write(addr, value)`
- Example code and projects
- Often large online forums for support



Example: Arduino (AVR based kit)