

CSE423: Embedded System Summer-2020

Introduction to micro-controller and other basic components

Microcontroller



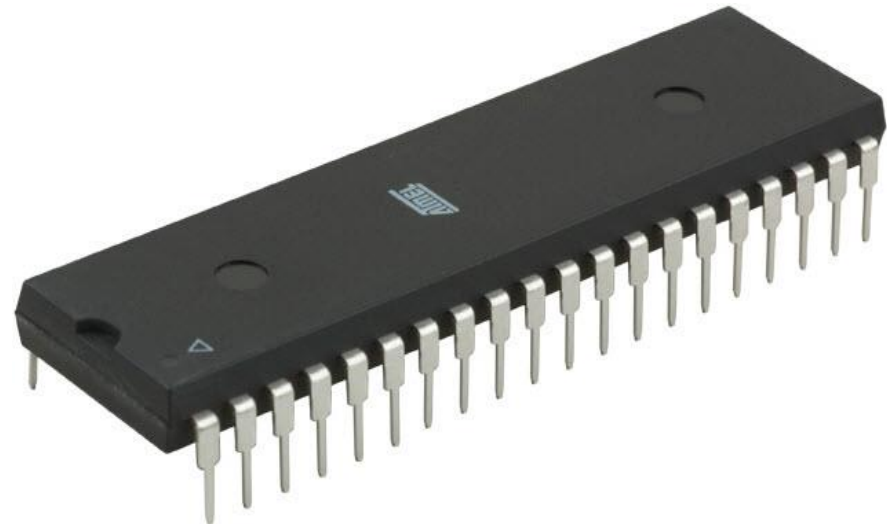
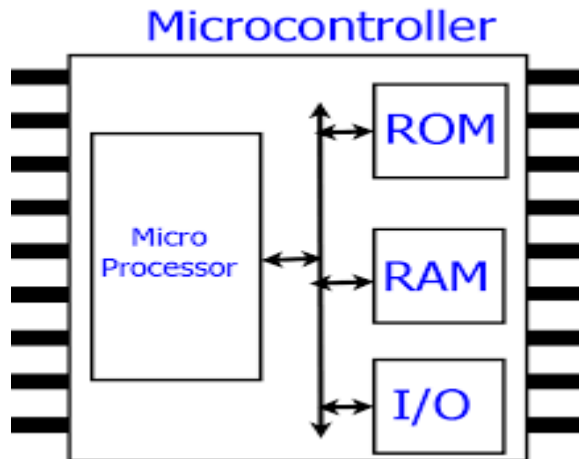
Lecture Objective



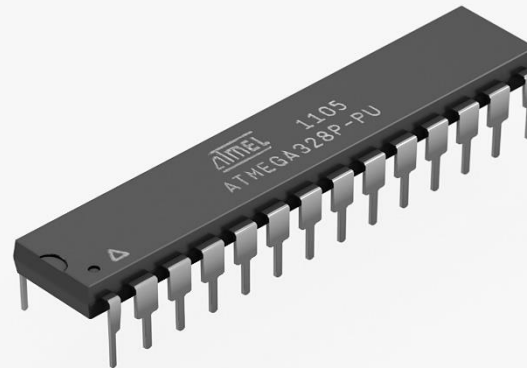
- **At the end of this course, students should be able to:**
 - *Interface a microcontroller to a variety of analog and digital inputs and output devices.*
 - *Program a microcontroller to implement a closed-loop automatic control.*
 - *Write and Troubleshoot programming language code for a microcontroller.*
 - *Analyze a problem to determine appropriate microcontroller use.*

What is Microcontroller?

- ❑ A microcontroller is an **integrated chip** that is often part of an embedded system.
- ❑ The microcontroller includes a **CPU, RAM, ROM, I/O ports** and **timers** like a standard computer, but because they are designed to execute only **a single specific task** to control a single system, they are much *smaller and simplified* so that they can include all the functions required on a single chip.



Microcontroller (Atmel ATmega 328P)



ATmega328P is a high performance yet low power consumption 8-bit AVR microcontroller that's able to achieve the most single clock cycle execution of 131 powerful instructions thanks to its advanced **RISC** architecture. It can commonly be found as a processor in Arduino boards such as [Arduino Fio](#) and [Arduino Uno](#).

Microcontroller (Atmel ATmega 328P)



Features:

High endurance non-volatile memory segments

- In system self-programmable flash program memory
- Programming Lock for software security

Peripheral features

- Two 8-bit Timer/Counter with separate prescaler, compare mode.
- One 16-bit Timer/Counter with separate prescaler, compare mode, and capture mode
- Temperature measurement
- Programmable serial USART and watchdog timer with separate on-chip oscillator.

Microcontroller (Atmel ATmega 328P)



Unique features compared to other microcontrollers (ARM, 8051, PIC):

- Power-on reset and programmable brown-out detection
- Internal calibrated oscillator
- External and Internal interrupt sources
- Six sleep modes: Idle, ADC noise reduction, power-save, power-down, standby, and extended standby

Microcontroller (Atmel ATmega 328P)



Advantages and Disadvantages:

Advantages

- Processors are simpler to use, with the usage of 8bit and 16bit instead of 32/64bit which are more complex.
- Readily usable without additional computing components with 32k bytes of onboard self-programmable flash program memory as well as 23 programmable I/O lines
- Code Efficient, all 31 registers are directly connected to the arithmetic logic unit (ALU), making it 10 times faster than conventional CISC microcontrollers
- Optimized for AVR enhanced RISC instruction set.




Disadvantages

- Lacks performance compared to higher bit microcontrollers

Microcontroller (Atmel ATmega 328P)



□ Comparison of different micro-controllers

	 ATmega328P	 STM32	 MSP430
Brand	MicroChip	Cortex	Texas Instruments
Cost	Low	High	Low
Architecture	Advanced RISC architecture	Power Architecture technology designed for embedded applications	Older, von-Neumann architecture
Power Consumption	Low, more efficient power consumption	Medium, higher clock speed may result in higher consumption power	Low
Performance	Medium, lower bit but suitable for complex projects	High, fast processing speed, packs more power. Running 32 bit ARM processor core with sufficient RAM	Low, more suitable for only simple projects
Ease of Usage	Easy to use, 8 bit and high compatibility with Arduino boards	Complicated due to its nature of being a 32 bit microcontroller	Complex relative to Arduino boards



Required Acquisition

- Arduino Uno**
- USB A to B Cable**
- Arduino IDE**
- Breadboard**
- Jumper Wire**
- Different Circuit Elements**

Required Acquisition

- Textbook
- [Arduino Uno](#)
- USB A to B Cable
- Arduino IDE
- Breadboard
- Jumper Wire
- Different Circuit Elements



Price: 590 BDT

- **For online order:** <https://www.techshopbd.com/product-categories/boards/1253/arduino-uno-r3-china-techshop-bangladesh>

Required Acquisition

- Textbook
- Arduino Uno
- [USB A to B Cable](#)
- Arduino IDE
- Breadboard
- Jumper Wire
- Different Circuit Elements

Price: **80 BDT**

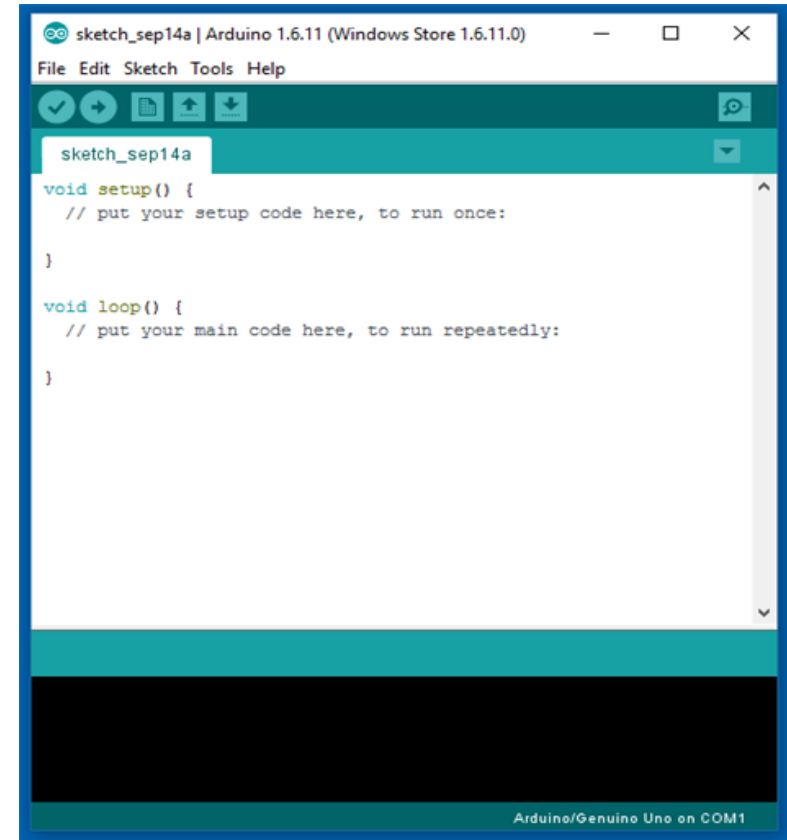


- **For online order:** <https://www.techshopbd.com/product-categories/cable/206/usb-cable-a-to-b-techshop-bangladesh>



Required Acquisition

- Textbook
- Arduino Uno
- USB A to B Cable
- [Arduino IDE](#)
- Breadboard
- Jumper Wire
- Different Circuit Elements

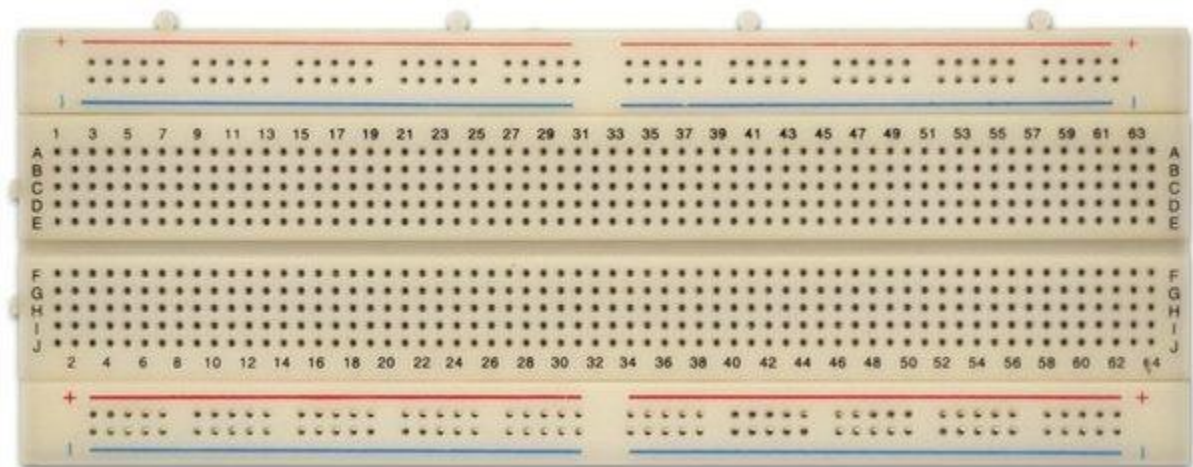


➤ **For download:** <https://www.arduino.cc/en/Main/Software>

Required Acquisition

- Textbook
- Arduino Uno
- USB A to B Cable
- Arduino IDE
- Breadboard
- Jumper Wire
- Different Circuit 1

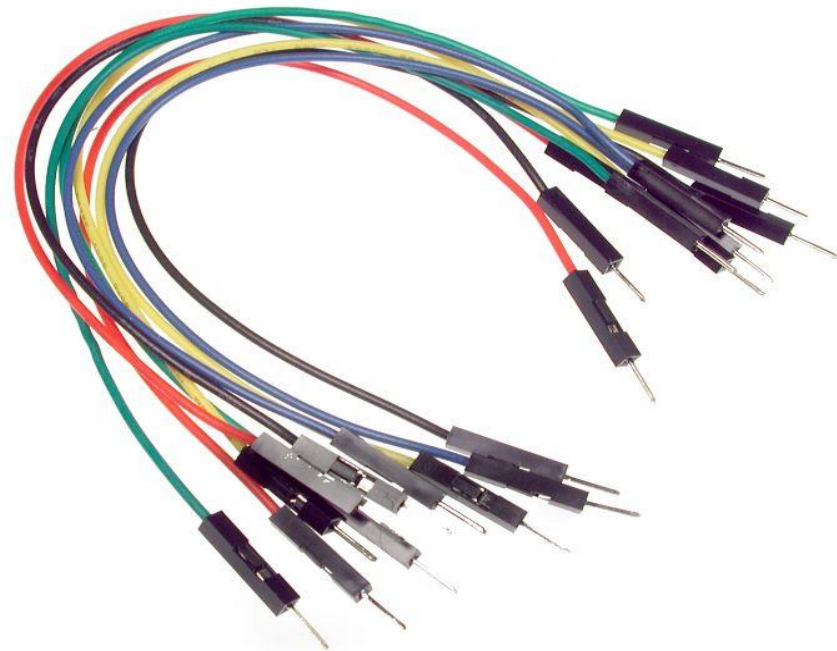
Price: 120 BDT



- **For online order:** <https://www.techshopbd.com/product-categories/project-board/231/breadboard-techshop-bangladesh>

Required Acquisition

- Textbook
- Arduino Uno
- USB A to B Cable
- Arduino IDE
- Breadboard
- Jumper Wire
- Different Circuit Elements

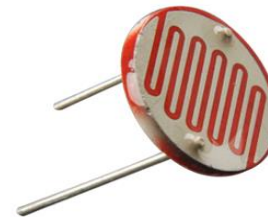
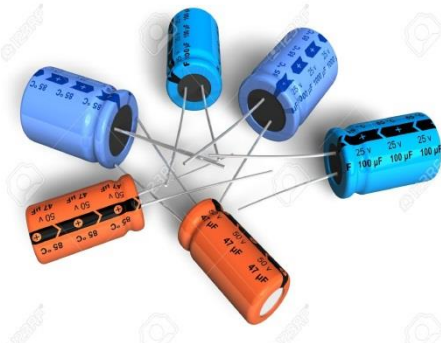
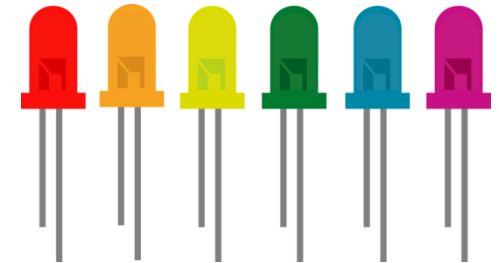


Price: **2.20 BDT** pre piece

- **For online order:** <https://www.techshopbd.com/product-categories/cable/1083/male-to-male-jumper-wire-single-techshop-bangladesh>

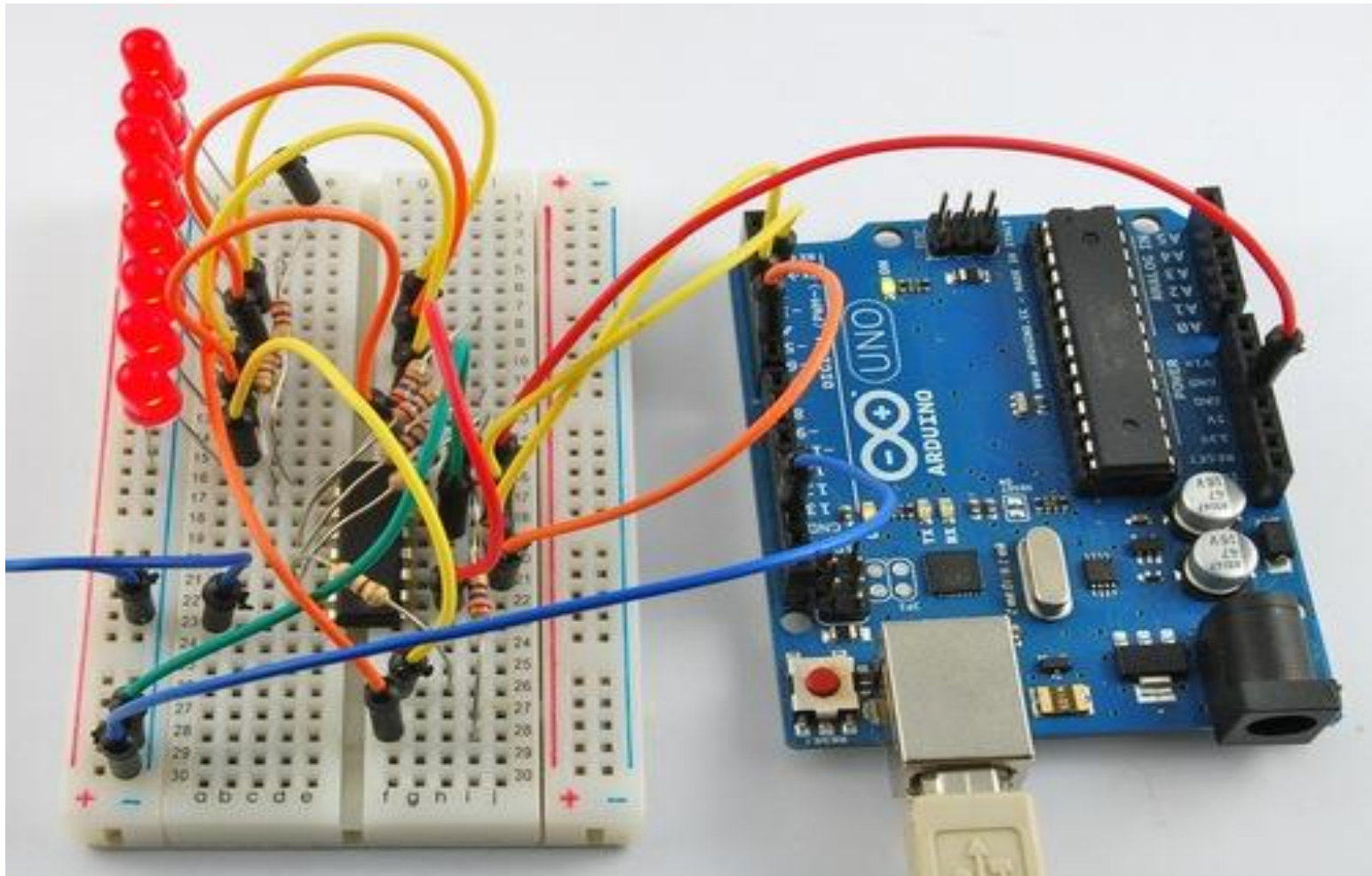
Required Acquisition

- Textbook
- Arduino Uno
- USB A to B Cable
- Arduino IDE
- Breadboard
- Jumper Wire
- [Different Circuit Elements](#)

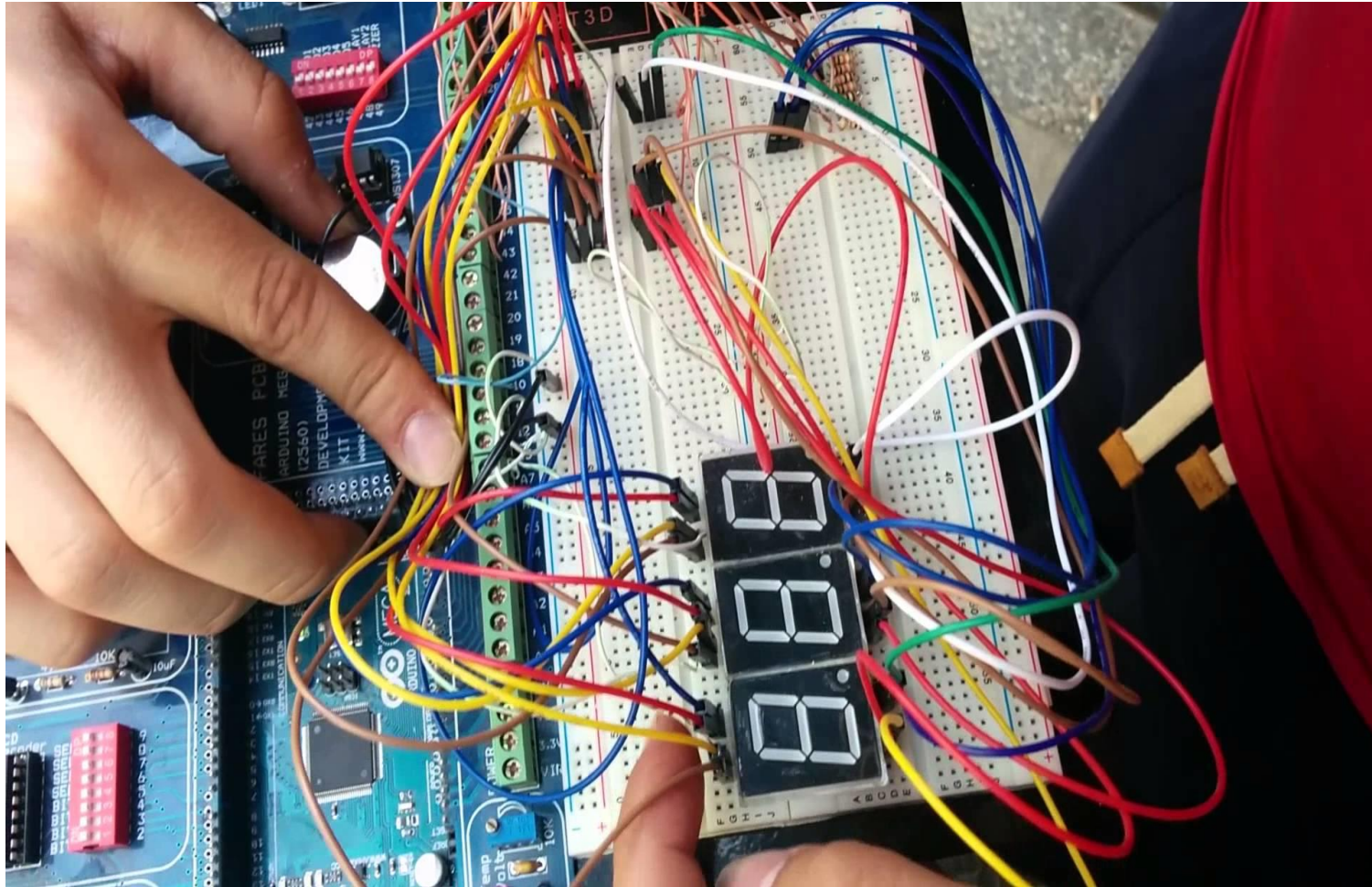


➤ For online order: <https://www.techshopbd.com/>

Example



Example



Appropriate Microcontroller Use



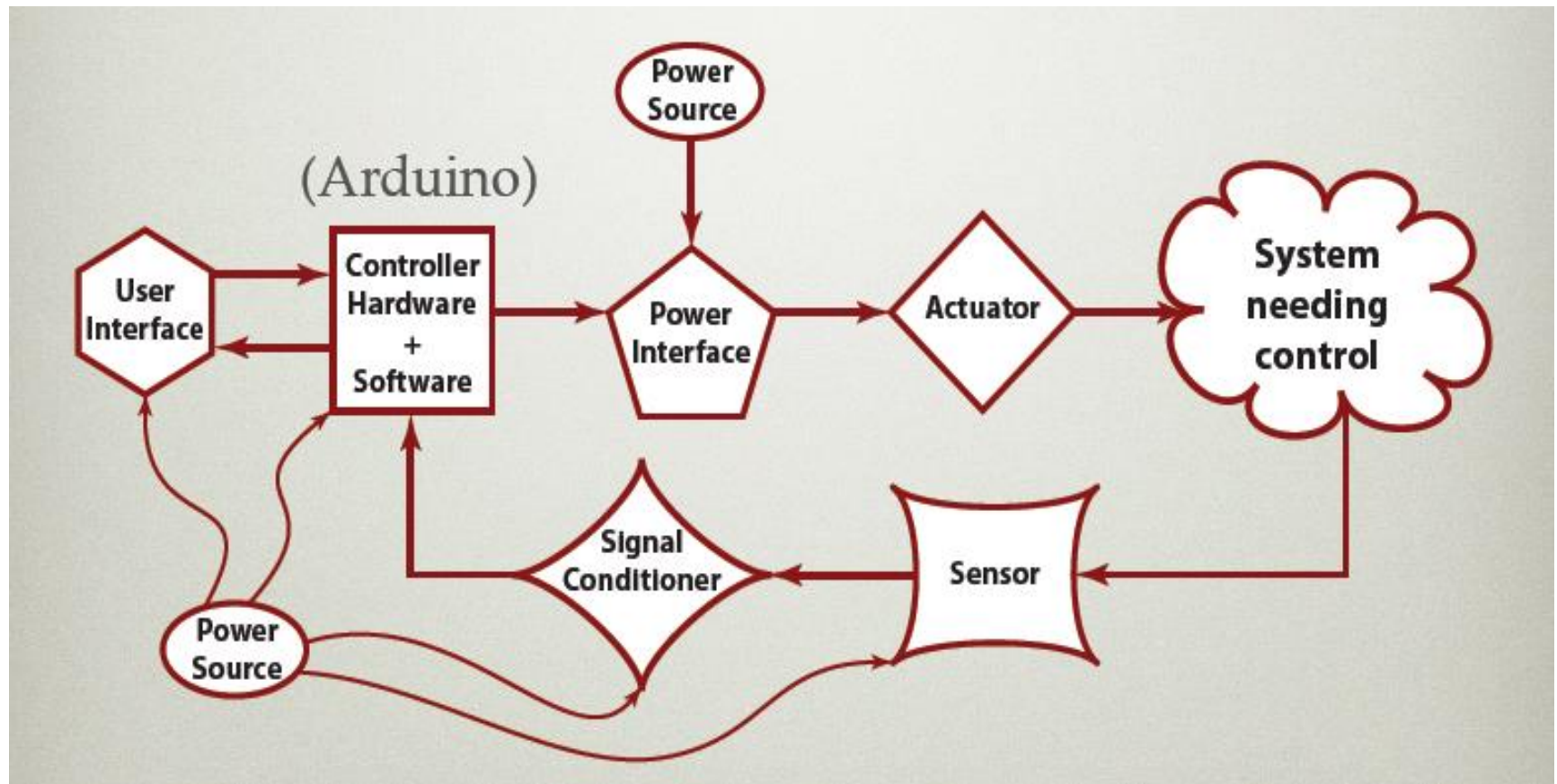
- A microcontroller is a correct tools to use when:
 - Intelligence is required in a system
 - The complexity of a system is reduced when using one.
 - The cost of the microcontroller is “less” then using discrete components to do the same job.
 - A variety of sensors and actuators must be integrated in the system
 - Communication with the other device is necessary

Appropriate Microcontroller Use



- A microcontroller is **NOT** the correct tool to use when:
 - System requires little or no intelligence.
 - The system can be made easier and/or cheaper using discrete components.
 - Microcontroller is undersized for the problem
 - Too slow
 - Too much number crunching required
 - Too many things going on

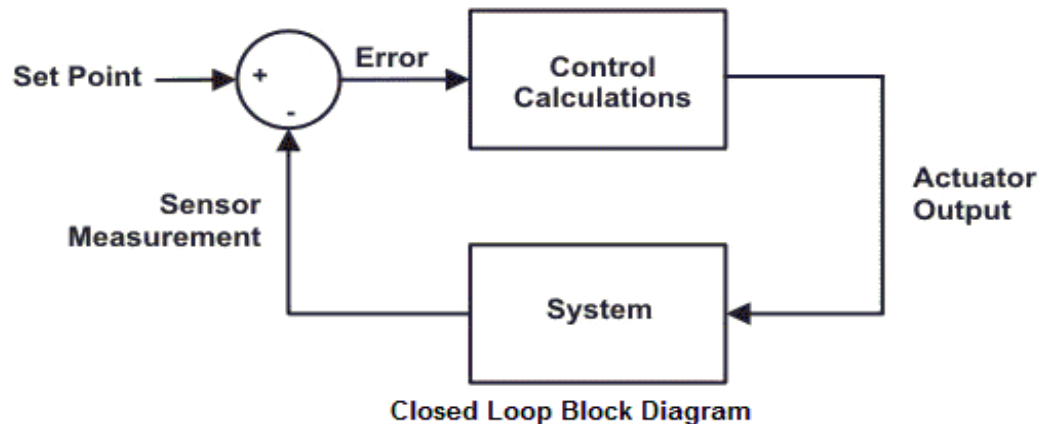
Embedded System Concept Map



Sensor + Signal Conditioner



- Required for “**Closed Loop Control**”.

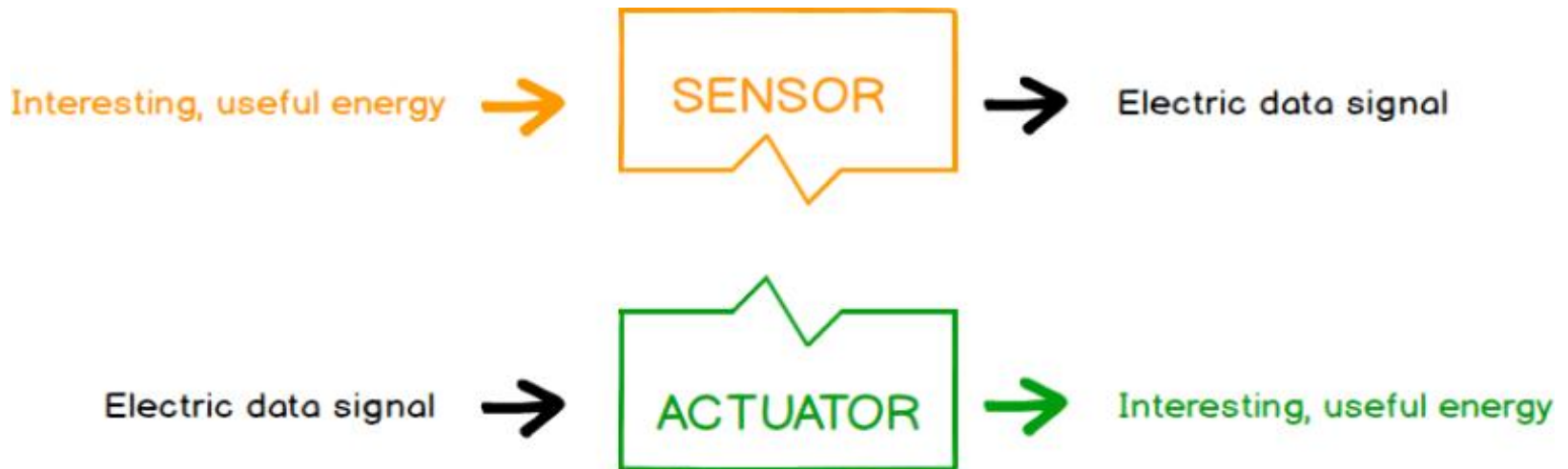


- (*What is the system called if it uses no sensors?*)
- Measures important system variable(s)
- These measurements may need to be conditioned for use by the “Brain”
- The conditioning involves **scaling**, **offsetting**, **filtering** etc. required for the controller to have meaningful data.



Actuator

- Energy conversion device
- Converts power to the kind needed by the controlled device.
- Motor, brake, pump, solenoid, linear actuator, flaps etc.
- **It is just opposite to sensor**





Controller Software

- C/C++/Arduino IDE for many functions
- Assembly language for high speed functions
- FPGA for highest speed (VHDL)



```
sketch_sep14a
void setup() {
  // put your setup code here, to run once:
}

void loop() {
  // put your main code here, to run repeatedly:
}
```

