ECE3411 – Fall 2016

Lecture 6c.

I²C
RedBot & DC Motor
Servo Motor Control

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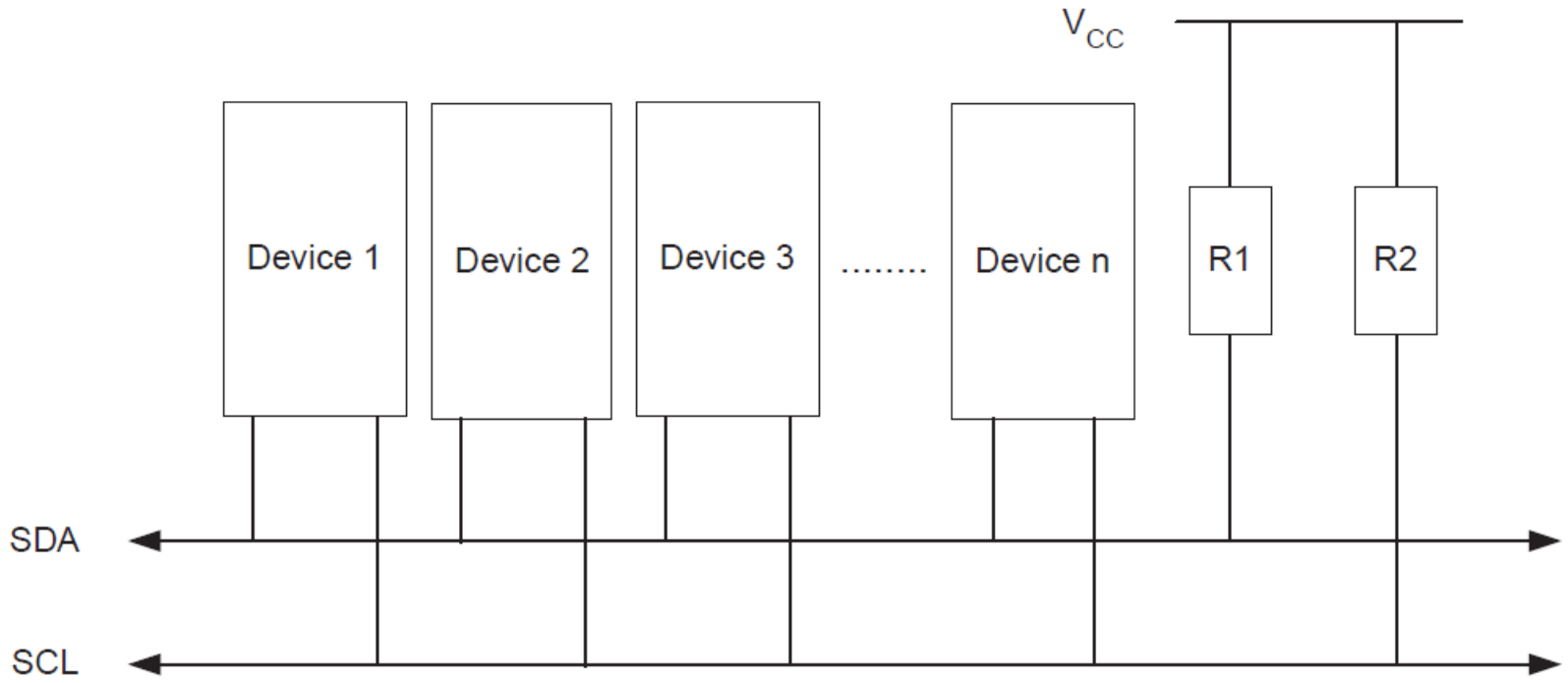
Slides on I2C and Servo Motor Control copied from Lecture 7b, ECE3411 – Fall 2015, by Marten van Dijk and Syed Kamran Haider
Slides on RedBot adapted from Wikipedia and "RedBot Project" offered by Sung Yuel Park in Spring 2016

UCONN

I^2C: Inter Integrated Circuit bus

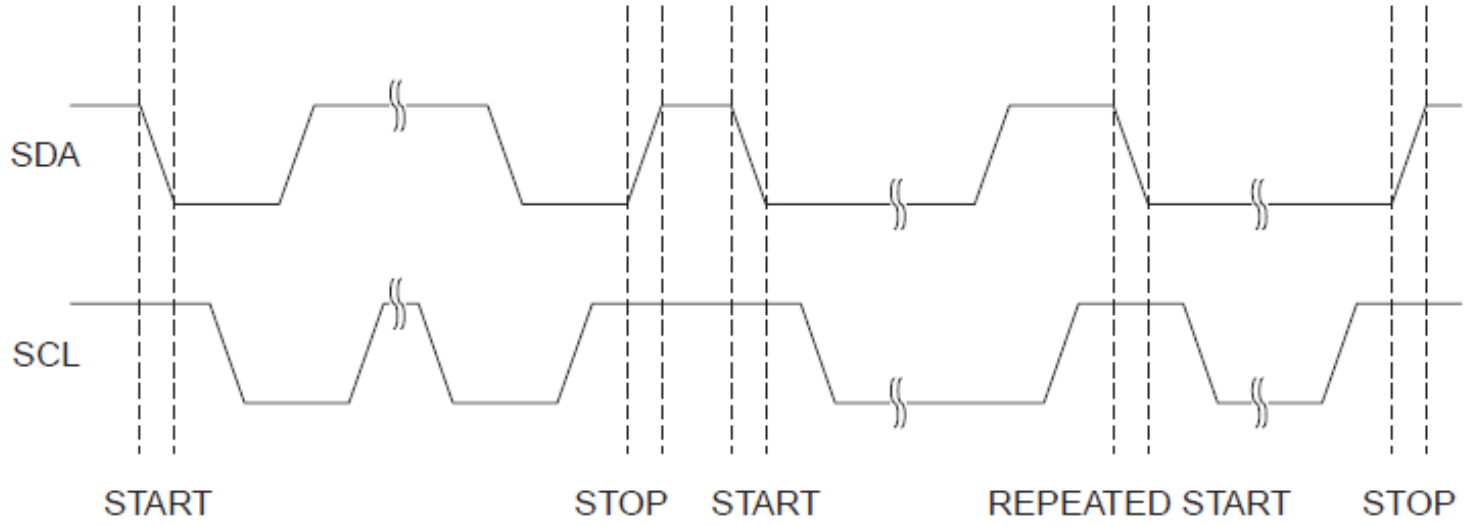
- Also known as Two Wire Interface (TWI)
- Allows up to 128 different devices to be connected using only two bi-directional bus lines, one for clock (SCL) and one for data (SDA).
- All devices connected to the bus have individual addresses.



I²C START and STOP Conditions

- START and STOP conditions are signaled by changing the level of the SDA line when the SCL line is high.
- When a new START condition is issued between a START and STOP condition, this is referred to as a REPEATED START condition

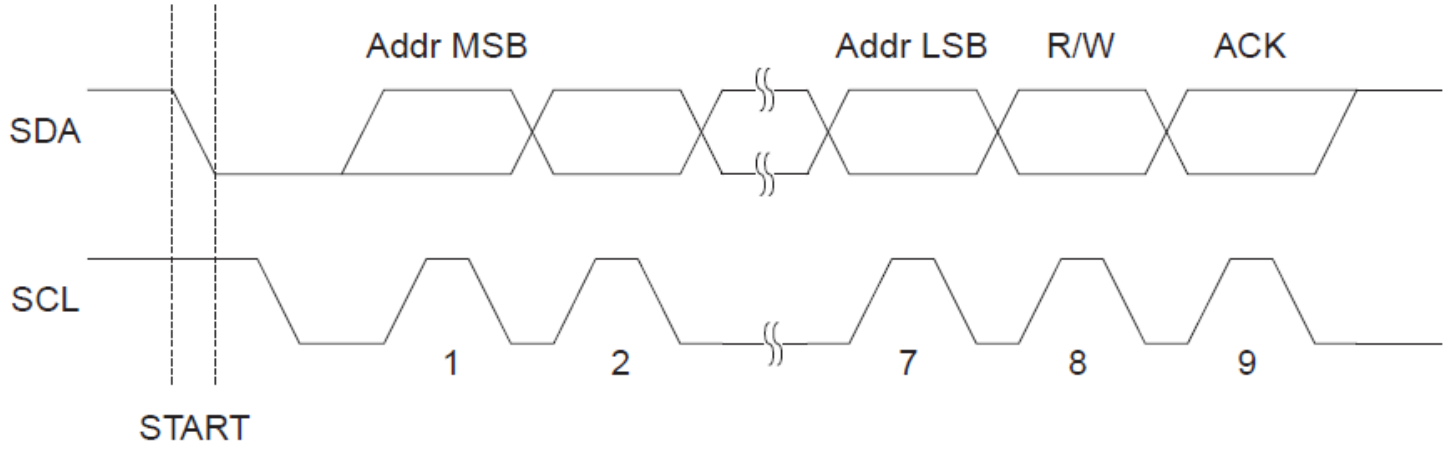
Figure 21-3. START, REPEATED START and STOP conditions



I²C Address Packet Format

- All address packets transmitted on the TWI bus are 9 bits long:
  - 7 address bits, one READ/WRITE control bit and an acknowledge bit.
- When a Slave recognizes that it is being addressed, it should acknowledge by pulling SDA low in the ninth SCL (ACK) cycle.
- The Master can then transmit a STOP condition (by pulling SDA high), or a REPEATED START condition to initiate a new transmission.

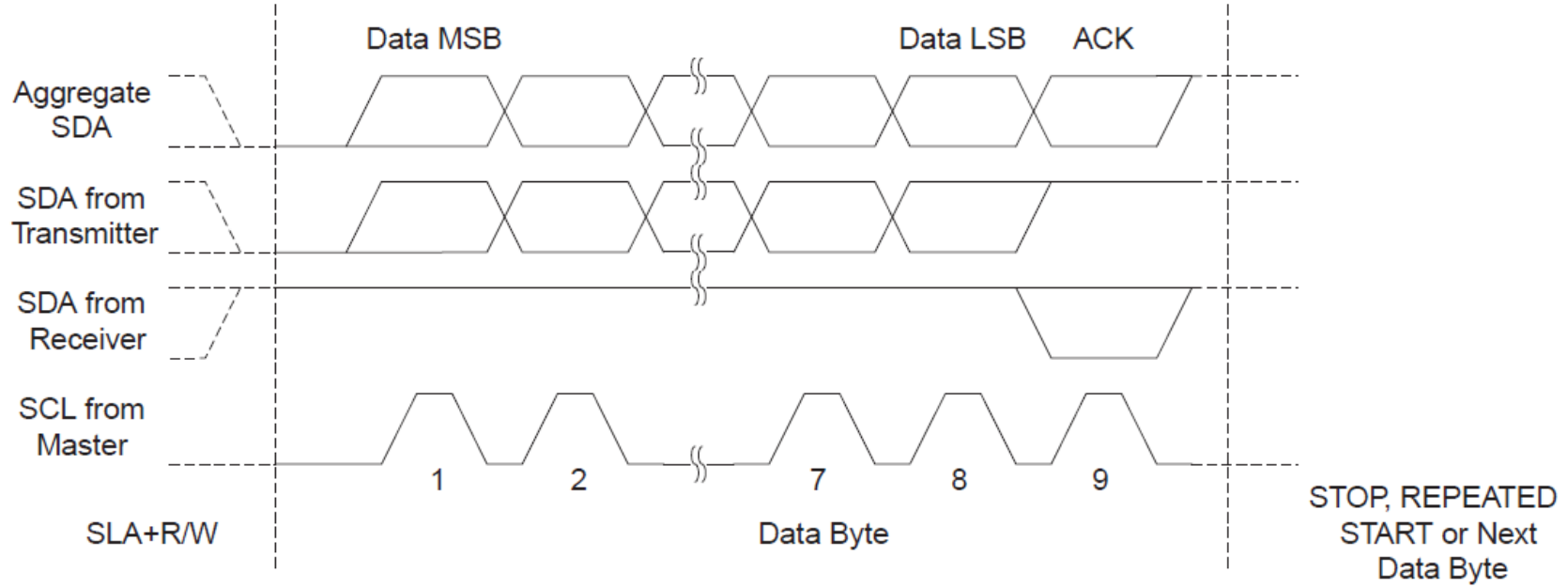
Figure 21-4. Address Packet Format



I²C Data Packet Format

- All data packets transmitted on the TWI bus are 9 bits long:
  - One data byte and one acknowledge bit.
- An Acknowledge (ACK) is signaled by the Receiver pulling the SDA line low during the ninth SCL cycle. If the Receiver leaves the SDA line high, a NACK is signaled.

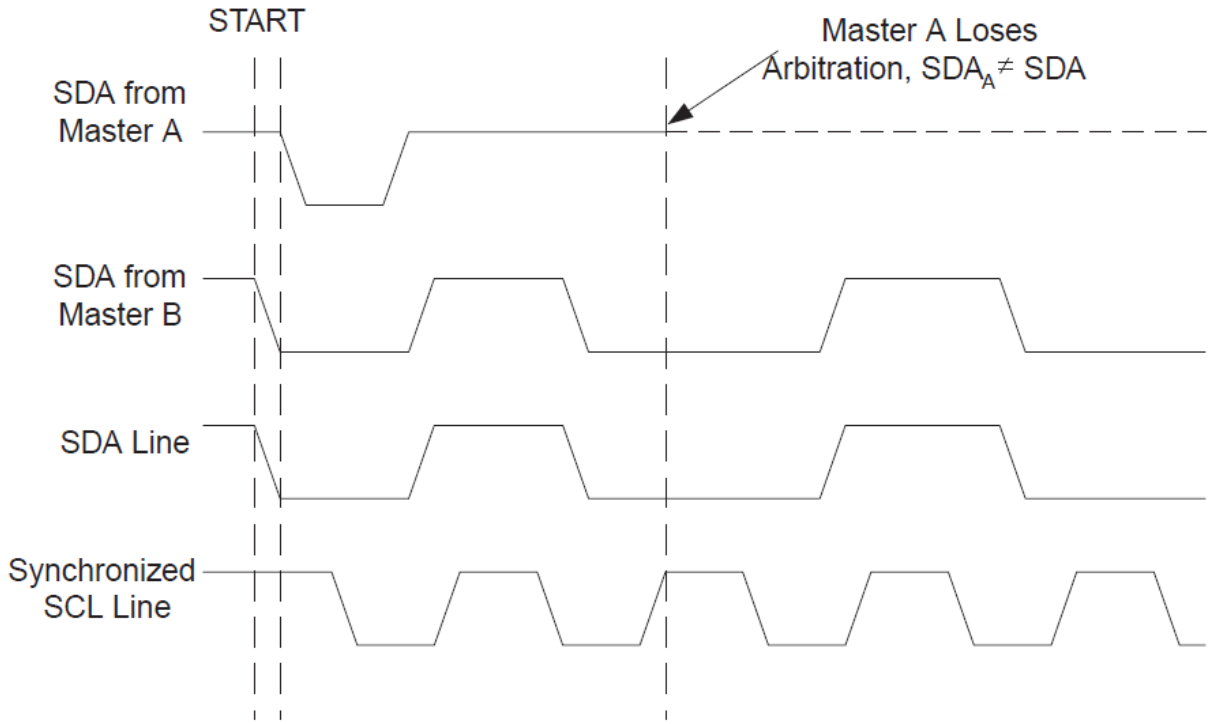
Figure 21-5. Data Packet Format



I^2C Bus Arbitration

- Arbitration is carried out by all masters (any device can become a master) continuously monitoring the SDA line after outputting data.
- If the value read from the SDA line does not match the value the Master had output, it has lost the arbitration.

Figure 21-8. Arbitration Between Two Masters



RedBot Project

Titles	AVR Functions	Additional HW	SW Scenario
Line Follower	ADC, PWM, GPIO, UART	IR Sensor, H-bridge driver	Based on IR sensor input, RedBot needs to move along a line (black electrical tape)

Requirements:

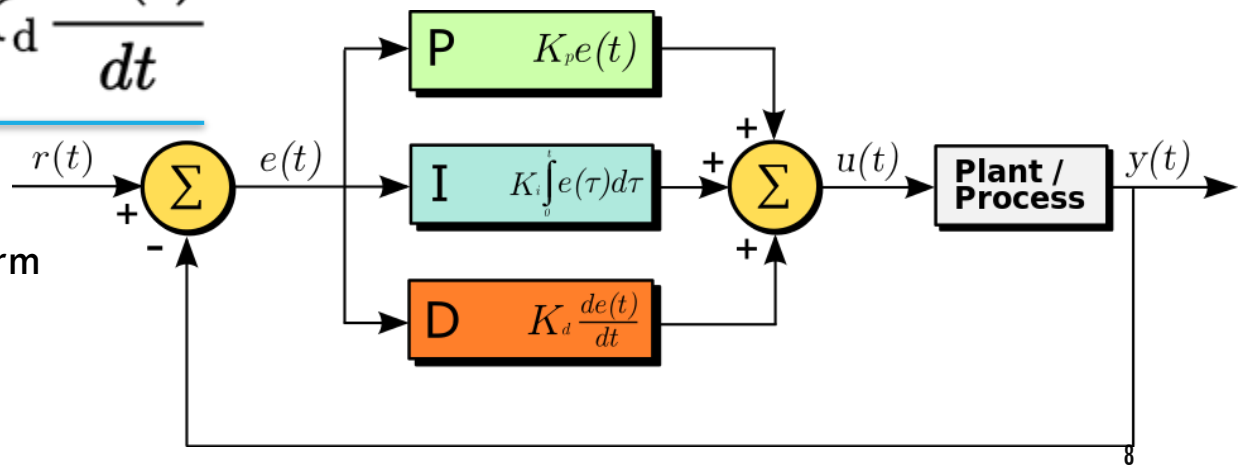
- Two students will be paired by a random algorithm. We do have some spare RedBots if any of you really wants to work individually.
- Demo your line follower on Dec. 7th.

PID Control

- A **proportional–integral–derivative controller** (PID controller) is a control loop feedback mechanism (controller) commonly used in industrial control systems.
- It continuously calculates an error value e(t) as the difference between a desired set-point and a measured process variable and applies a correction based on proportional, integral, and derivative terms.
  - e(t) = |(max possible "blackness" measured by the line sensor) – (currently measured "blackness" by the line sensor) |
  - u(t) = is the correcting rotation speed of the vehicle (measured as the duty cycle)

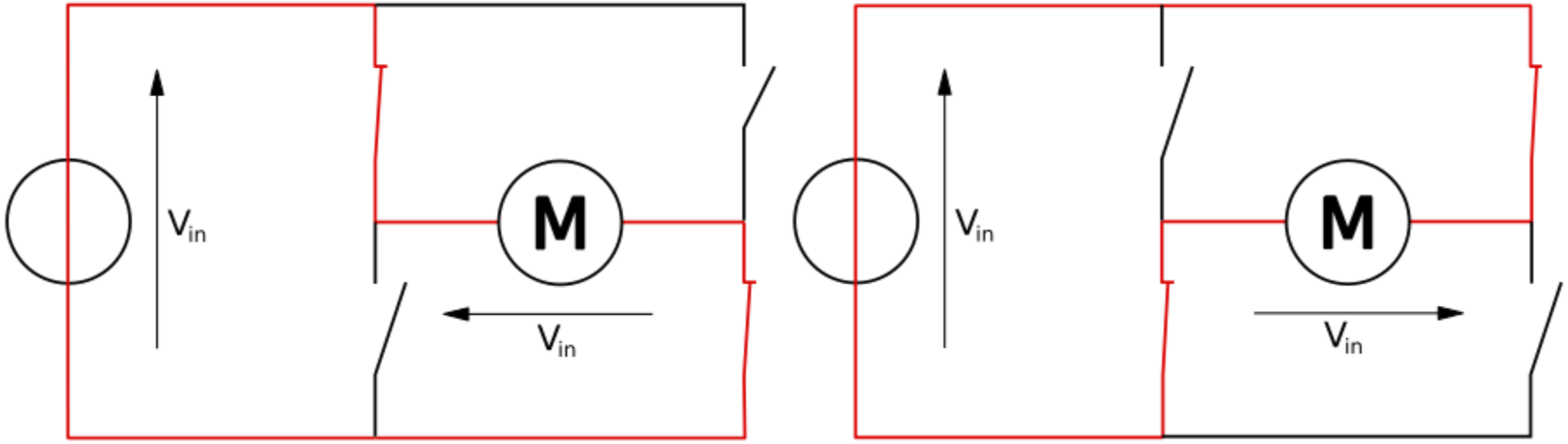
$$u(t) = K_\mathrm{p} e(t) + K_\mathrm{i} \int_0^t e(\tau)\,d\tau + K_\mathrm{d} \frac{de(t)}{dt}$$

Proportional Term Integral Term Derivative Term



H Bridges

- An H bridge enables a voltage to be applied across a load in either direction. It is widely used in robotics to allow DC motors to run forwards or backwards.



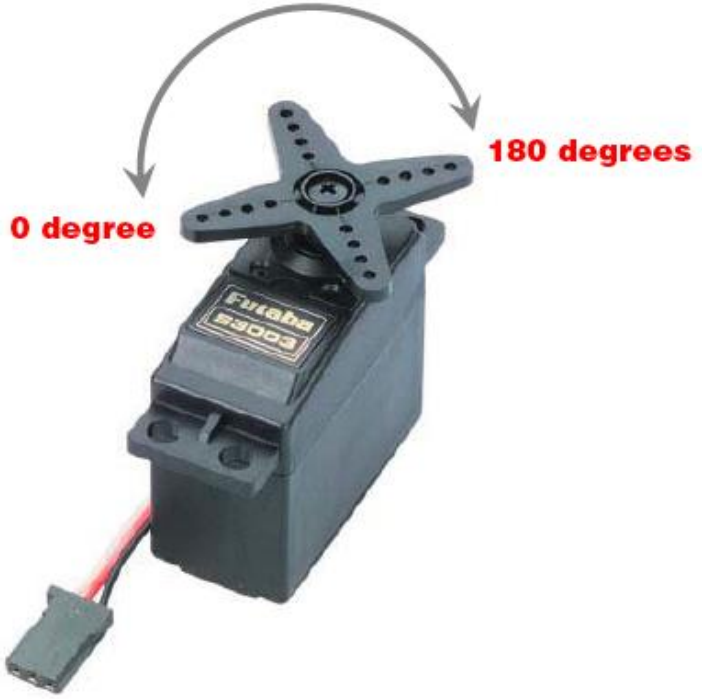
Go forward

Go backward

In RedBot, the control signals of an H bridge will be derived from two GPIO signals and a PWM signal. The two GPIO signals control how this motor is connected in this H bridge, and the duty cycle of the PWM signal controls how often it is connected. So, GPIOs control the direction, and PWM signal controls the speed.

Servo Motor

- A Servo is a small device that has an output shaft that can be positioned to specific angular positions based on input PWM signal.
- The servo motor has a potentiometer that is connected to the output shaft and allows the control circuitry to monitor the current angle of the servo motor.
- A normal servo is used to control an angular motion of between 0 and 180 degrees.



Ref: http://lizarum.com/assignments/physical_computing/2008/servo.html

Servo Motor Applications

- Servos are typically used to control elevators, rudders and ailerons.

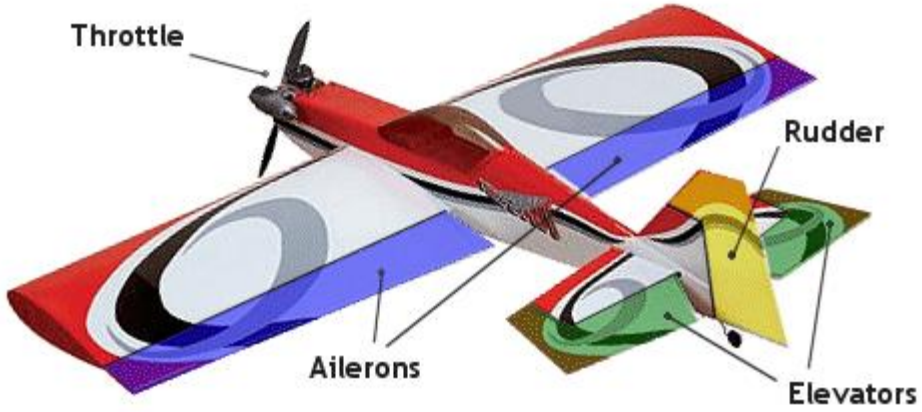
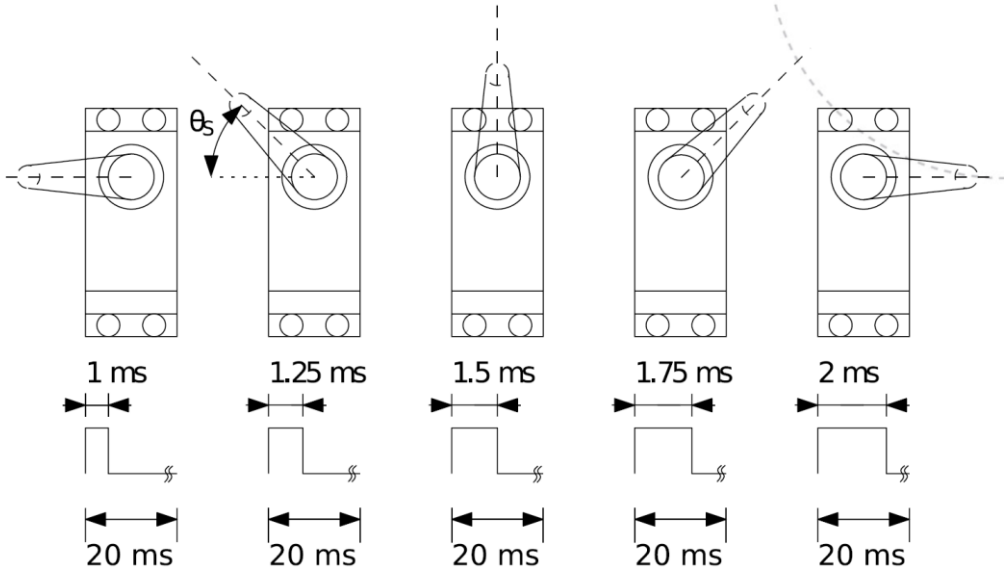


Image Refs: http://www.greatplanes.com/discontinued/gpma1414.html
http://www.rc-airplane-world.com/rc-airplane-controls.html

Controlling the servo

- The servo is controlled using a 50 Hz PWM signal (i.e. signal period = 20 ms)
- The angle of the servo is determined by the pulse width (i.e. the duty cycle)
  - 1.5ms corresponds to the center position.
- By varying the pulse width, we can control the angle
- The pulse width must never be outside the range 0.9 to 2.1ms



Connecting the servo

- Typically the servo connectors have 3 wires which should be connected as follows:
  - Red → VCC (+5V)
  - Black → GND (0V)
  - Yellow → PWM signal