



**Near East University**

*Yakın Dođu Üniversitesi, Lefkoşa KKTC*

# **BIONIC HAND**

**GRADUATION PROJECT**

**BME-402**

Murat Emre Bayramođlu

Kaan Tol

Mansoor Hayat Malik

Nicosia-2014

## Abstract

The idea of this Project comes from the Nuclear medicine and microbiology of hospitals where the staff is always exposed to life threatening conditions. It can be improved to reduce labour costs and Provide a safer working environment in health sector or various other sectors. This Project will enable staff to continue routine Works without being exposed to danger.

The Project consist of two parts consisting of sender and reciever. The sender part consist of a gloove with flex sensors embeded on its top. The user will be wearing the gloove and signals taken from the flex sensor will be transmitted wirelessly to the reciever part. The reciever part will take the signals and operate the servo motors with the help of these signals controlled by microprocessors.

The Project can be further improved in future with the addition of EMG signal operating arm leading to the creation of a bionic arm. It can also be used in Nuclear medicine for filling the doses of radioactive materials. In the end, It can be used in microbiology to perform experiments.

## Table Of Contents

A. CONTROL GLOVE .....	4
1. Flex Sensor.....	4
Summary .....	4
Conductive Ink-based.....	4
Properties.....	5
Applications.....	6
Fiber-optic .....	6
Properties.....	6
Applications.....	7
Conductive Fabric/Thread/Polymer-based .....	7
2. Arduino .....	8
Overview .....	8
Summary .....	9
Schematic & Reference Design.....	9
Power.....	9
Memory .....	10
Input and Output.....	10
Communication .....	11
Programming .....	11
Automatic (Software) Reset .....	12
USB Overcurrent Protection.....	12
Physical Characteristics.....	12
3. XBee Wireless Module .....	13
Overview .....	13
Jumper Settings .....	13
Networking.....	14
4. Circuit Diagram.....	17
5. Materials.....	17
6. The Values .....	20
B. ARDUINO WIRELESS BIONIC HAND .....	23
1. Arduino User Guide .....	23
1   Get an Arduino board and USB cable .....	23
2   Download the Arduino environment .....	23

3   Connect the board .....	23
4   Install the drivers .....	23
5   Launch the Arduino application .....	24
6   Open the blink example .....	25
7   Select your board .....	25
8   Select your serial port .....	26
9   Upload the program .....	26
2. XBee Wireless Module For Robotic Hand .....	28
3. Servo Motors .....	28
4. Circuit Diagram For Receiver Part .....	31
5. Code.....	32
6. Materials For Bionic Part .....	35
C. MATERIAL LIST .....	37

## A. CONTROL GLOVE

### 1. Flex Sensor

#### Summary

---

**Flexion sensors**, (from Latin *flectere*, 'to bend') also called **bend sensors**, measure the amount of deflection caused by bending the sensor. There are various ways of sensing deflection, from strain-gauges to hall-effect sensors. The three most common types of flexion sensors are:

- conductive ink-based
- fibre-optic
- conductive fabric/thread/polymer-based

A property of bend sensors worth noting is that bending the sensor at one point to a prescribed angle is not the most effective use of the sensor. As well, bending the sensor at one point to more than 90° may permanently damage the sensor. Instead, bend the sensor around a radius of curvature. The smaller the radius of curvature and the more the whole length of the sensor is involved in the deflection, the greater the resistance will be (which will be much greater than the resistance achieved if the sensor is fixed at one end and bent sharply to a high degree). In fact, Infusion Systems define the sensing parameter as “flex angle multiplied by radius”.

#### Specifications

A typical bend sensor has the following basic specifications:

- range of deflection
- uni- vs. bi-directional sensing
- uni- vs. bi-polar sensing
- range of resistance (nominal to full-deflection)

**Range of deflection:** Determines the maximum angle of deflection that can be measured (as opposed to the maximum angle the sensor can be bent).

**Uni- vs. bi-directional sensing:** Some flexion sensors increase the resistance when bent in either of two opposing directions, however there is no difference in the measurement with respect to the direction.

**Uni- vs. bi-polar sensing:** A bi-polar flexion sensor measures deflection in two opposing directions yielding different measurements.

**Range of resistance:** Bend sensors can vary largely (even the same product) in terms of their range of resistance, measured as the difference from nominal resistance to resistance at full deflection.

#### Conductive Ink-based

---

These types of bend sensors are passive resistive devices typically fabricated by laying a strip of resistive ink on a flexible plastic substrate, shaped as a thin, flexible stripe in lengths between 1” and 5”. At rest (when laid flat), the bend sensor is characterized by an intrinsic resistance. As the sensor is bent, the resistive materials inside it are pulled further apart. Fewer adjacent resistive particles come into contact, thereby increasing the resistance.

Typically, the nominal resistance lays between 10k $\Omega$  and 50k $\Omega$  and increases by a factor of 10 at full deflection.

Within the layers of the flex sensor substrate is a printed pattern of conductive ink. To conduct electricity, this ink contains carbon, or silver, particles mixed into a pigmented medium. Typically, the carbon particles are suspended in the ink to avoid fading of the pigment over time. This type of ink can also be safely applied to paper to avoid absorption into the fibers, thus changing the paper's properties. However, the carbon particles may be sensitive to changes in humidity that can lead to smudging of the ink

Most conductive ink-based bend sensors on the market are unipolar devices, that is the resistance increases as the deflection increases in one direction, and is unchanged if bent in the other direction. Placing two devices back-to-back will allow bipolar measurements for capturing deflections in both directions. Hysteresis and noise in resistance value are small if not entirely negligible.

Flexpoint Sensor Systems Inc. makes the Bend Sensor<sup>®</sup> in 1", 2", and 3" lengths. They are available with connectors that can be interfaced with standard sized headers.

As length increases, the intrinsic resistance goes up, as does the resistance for each sensor at full deflection. As well, there are different lamination and coating options to increase durability and stiffness. For mechanical and electrical design guides, refer to these links: [mechanical specs](#) and [electronic specs](#).

Images Scientific Instruments offers the bipolar flexion sensor FLX-02, which increases resistance in one direction and decreases resistance in the other direction. In addition, Images SI sells a special component-based flexion sensor which can also be used as a pressure sensor. This sensing principle is identical to conductive/thread/polymer-based sensing illustrated below. Worth mentioning is the online tutorial on how to construct a bi-directional (not: bi-polar!) bend sensor using a stripe of resistive material which is sandwiched between two copper clad laminates and sealed using heat shrink tubing.



Infusion Systems sells piezo-resistive bend sensors that work with greater ranges of deflection (larger flex angles), though at a higher cost. One example is the BendShort v2.0 sensing bi-polar deflection from -180 to +180 degrees.



---

## Properties

- hysteresis/noise neglectible

- resistance is function of radius of curvature, not angle at one point
- high temperature and humidity-tolerance
- relatively low cost
- customizable (coatings, laminating materials)

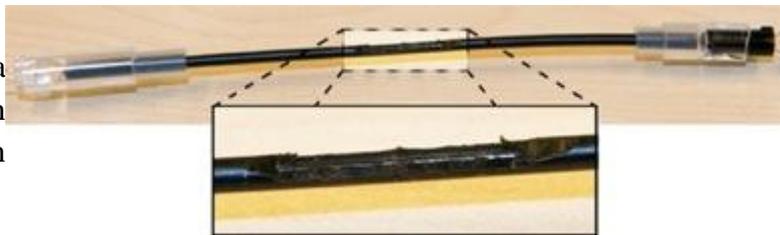
### Applications

- automotive applications
- industrial applications, e.g. safety switches, shipping, machine control
- medical applications (e.g. “SmartBed”)
- gaming devices
- measuring devices
- assistive technology
- robotics

### Fiber-optic

Fiber-optic bend sensors (also called optical goniometers) consist of a light source, a plastic optical fibre (POF) with an abraded section and a photosensitive detector. Light is emitted into the POF at one end and sensed at the other end. Bending the optical fibre results in a loss of light (intensity). The loss of light is often enhanced by cutting, polishing or abrading a part of the POF. Due to the sensing principle single fiber-optical bend sensors are uni-polar devices.

The image on the right shows a fiber-optic bend sensor with an abraded section as used in TWEND.



A bend sensor can also be made from a length of fiber optic cable with an LED and a photodiode placed at both ends of a section of cable; Here is a link where fiber optic cable can be purchased and the data sheet is available

Measurand Inc. offers several products employing fiber-optic bend-sensing. TheShapetape, for example, generates spatial information entirely from bend and twist information using an array of pairs of fiber optic sensors in a rubber coating. Each sensor pair integrates curvature and reports the net angular difference (NAD). NAD is used to calculate the cartesian coordinates (x,y,z) of the end of the pair relative to its start. Accordingly, the spatial sensor density determines the smallest features that may be measured accurately.

La Kitchen used to sell a fiber optical flex sensor which can be bent in any direction and senses global deflection. Unfortunately, La Kitchen has closed its doors.

### Properties

- mostly custom-built or developed in the lab
- high repeatability, hysteresis neglectible

- can be bent in any direction
- usually unipolar measurement (global flexion)
- can be expensive

### Applications

- medical applications
- educational studies

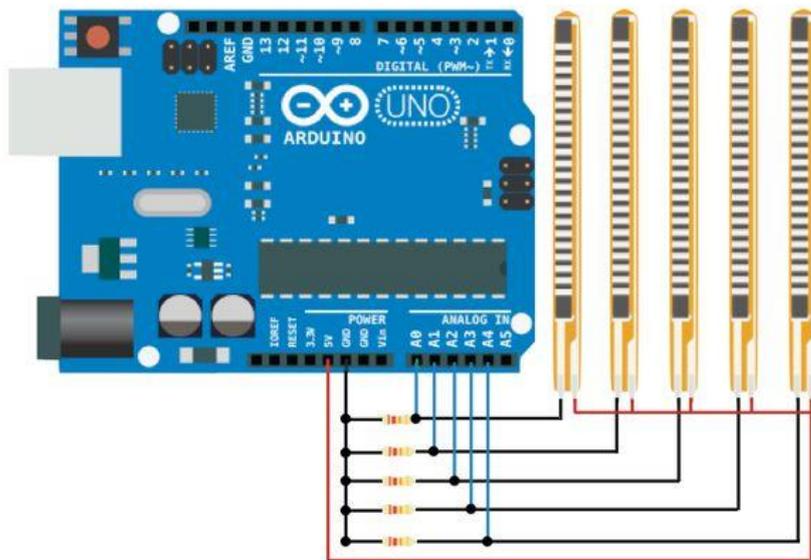
### Conductive Fabric/Thread/Polymer-based

Conductive fabric-, thread- or polymer-based flexion sensors typically consist of two layers of conductive material with a layer of resistive material (e.g. Velostat) in between. It is mostly sandwiched inbetween layers of more rugged material, e.g. Neoprene. As pressure is applied (directly or by bending) the two layers of conductive material get pushed closer together and the resistance of the sensor decreases. This sensing mechanism is similar to force-sensitive resistors. Strictly speaking, these types of sensors are pressure sensors which also sense deflection (pressure as a function of deflection): bending the sensor across an angle of a rigid structure results in stretch of the sensor material which exerts pressure onto the sensor. It is this pressure that is measured. Foam/Polymer-based sensors decrease their nominal resistance as the material is compressed. These sensors are known to have poor accuracy, repeatability and hysteresis<sup>6</sup>). External links to distributors and manufacturers of conductive fabric/thread can be found at the bottom of this page.

### Properties

- quasi-linear behaviour for pressure-sensing
- slow response, due to physical deformation (internal energy)
- high hysteresis, poor accuracy & repeatability
- high temperature- and humidity-tolerance (can be used underwater)
- highly customizable
- cheap

conductive ink	fibre-optic	fabric/polymer
+ robust & durable	+ accurate, repeatable measurements	+ attractive physical qualities
- fixed lengths, drift	- requires light-source & detector	- poor & variable performance



## 2. Arduino

### Overview

The Arduino Uno is a microcontroller board based on the ATmega328 ([datasheet](#)). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

[Revision 2](#) of the Uno board has a resistor pulling the 8U2 HWB line to ground, making it easier to put into [DFU mode](#).

[Revision 3](#) of the board has the following new features:

- 1.0 pinout: added SDA and SCL pins that are near to the AREF pin and two other new pins placed near to the RESET pin, the IOREF that allow the shields to adapt to the voltage provided from the board. In future, shields will be compatible with both the board that uses the AVR, which operates with 5V and with the Arduino Due that operates with 3.3V. The second one is a not connected pin, that is reserved for future purposes.
- Stronger RESET circuit.
- Atmega 16U2 replace the 8U2.

"Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform; for a comparison with previous versions, see the [index of Arduino boards](#).

## Summary

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328)
EEPROM	1 KB (ATmega328)
Clock Speed	16 MHz

## Schematic & Reference Design

EAGLE files: [arduino-uno-Rev3-reference-design.zip](#) (NOTE: works with Eagle 6.0 and newer)

Schematic: [arduino-uno-Rev3-schematic.pdf](#)

Note: The Arduino reference design can use an Atmega8, 168, or 328, Current models use an ATmega328, but an Atmega8 is shown in the schematic for reference. The pin configuration is identical on all three processors.

## Power

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically.

External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using

more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The power pins are as follows:

- VIN. The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- 5V. This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage your board. We don't advise it.
- 3V3. A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- GND. Ground pins.
- IOREF. This pin on the Arduino board provides the voltage reference with which the microcontroller operates. A properly configured shield can read the IOREF pin voltage and select the appropriate power source or enable voltage translators on the outputs for working with the 5V or 3.3V.

## Memory

The ATmega328 has 32 KB (with 0.5 KB used for the bootloader). It also has 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the [EEPROM library](#)).

## Input and Output

Each of the 14 digital pins on the Uno can be used as an input or output, using [pinMode\(\)](#), [digitalWrite\(\)](#), and [digitalRead\(\)](#) functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

- Serial: 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.
- External Interrupts: 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the [attachInterrupt\(\)](#) function for details.
- PWM: 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the [analogWrite\(\)](#) function.
- SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication using the [SPI library](#).
- LED: 13. There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though

is it possible to change the upper end of their range using the AREF pin and the [analogReference](#) function. Additionally, some pins have specialized functionality:

- TWI: A4 or SDA pin and A5 or SCL pin. Support TWI communication using the [Wire library](#).

There are a couple of other pins on the board:

- AREF. Reference voltage for the analog inputs. Used with [analogReference](#).
- Reset. Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

See also the [mapping between Arduino pins and ATmega328 ports](#). The mapping for the ATmega8, 168, and 328 is identical.

## Communication

The Arduino Uno has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The '16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, [on Windows, a .inf file is required](#). The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial communication on pins 0 and 1).

A [SoftwareSerial library](#) allows for serial communication on any of the Uno's digital pins. The ATmega328 also supports I2C (TWI) and SPI communication. The Arduino software includes a [Wire library](#) to simplify use of the I2C bus; see the [documentation](#) for details. For SPI communication, use the [SPI library](#).

## Programming

The ATmega328 on the Arduino Uno comes preburned with a [bootloader](#) that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol

You can also bypass the bootloader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header;

The ATmega16U2 (or 8U2 in the rev1 and rev2 boards) firmware source code is available . The ATmega16U2/8U2 is loaded with a DFU bootloader, which can be activated by:

- On Rev1 boards: connecting the solder jumper on the back of the board (near the map of Italy) and then resetting the 8U2.
- On Rev2 or later boards: there is a resistor that pulling the 8U2/16U2 HWB line to ground, making it easier to put into DFU mode.

You can then use [Atmel's FLIP software](#) (Windows) or the [DFU programmer](#) (Mac OS X and Linux) to load a new firmware. Or you can use the ISP header with an external programmer (overwriting the DFU bootloader). See [this user-contributed tutorial](#) for more information.

### **Automatic (Software) Reset**

Rather than requiring a physical press of the reset button before an upload, the Arduino Uno is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the ATmega8U2/16U2 is connected to the reset line of the ATmega328 via a 100 nanofarad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino software uses this capability to allow you to upload code by simply pressing the upload button in the Arduino environment. This means that the bootloader can have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload.

This setup has other implications. When the Uno is connected to either a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via USB). For the following half-second or so, the bootloader is running on the Uno. While it is programmed to ignore malformed data (i.e. anything besides an upload of new code), it will intercept the first few bytes of data sent to the board after a connection is opened. If a sketch running on the board receives one-time configuration or other data when it first starts, make sure that the software with which it communicates waits a second after opening the connection and before sending this data.

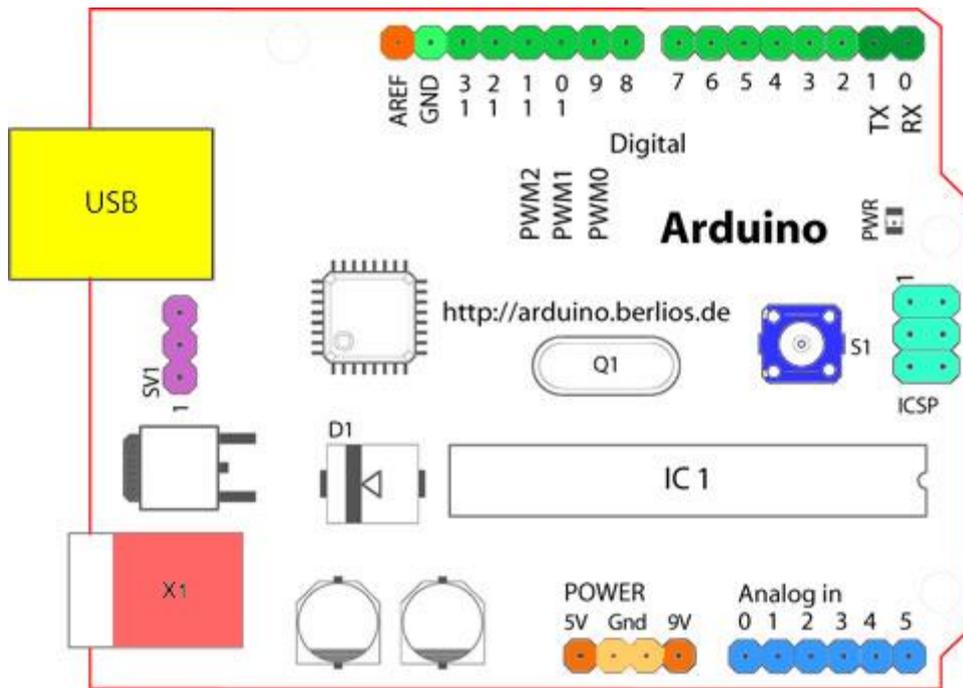
The Uno contains a trace that can be cut to disable the auto-reset. The pads on either side of the trace can be soldered together to re-enable it. It's labeled "RESET-EN". You may also be able to disable the auto-reset by connecting a 110 ohm resistor from 5V to the reset line;

### **USB Overcurrent Protection**

The Arduino Uno has a resettable polyfuse that protects your computer's USB ports from shorts and overcurrent. Although most computers provide their own internal protection, the fuse provides an extra layer of protection. If more than 500 mA is applied to the USB port, the fuse will automatically break the connection until the short or overload is removed.

### **Physical Characteristics**

The maximum length and width of the Uno PCB are 2.7 and 2.1 inches respectively, with the USB connector and power jack extending beyond the former dimension. Four screw holes allow the board to be attached to a surface or case. Note that the distance between digital pins 7 and 8 is 160 mil (0.16"), not an even multiple of the 100 mil spacing of the other pins.



### 3. XBee Wireless Module

#### Overview

The Xbee shield allows an Arduino board to communicate wirelessly using Zigbee. It is based on the Xbee module from MaxStream. The module can communicate up to 100 feet indoors or 300 feet outdoors (with line-of-sight). It can be used as a serial/usb replacement or you can put it into a command mode and configure it for a variety of broadcast and mesh networking options. The shields breaks out each of the Xbee's pins to a through-hole solder pad. It also provides female pin headers for use of digital pins 2 to 7 and the analog inputs, which are covered by the shield (digital pins 8 to 13 are not obstructed by the shield, so you can use the headers on the board itself).

The Xbee shield was created in collaboration with Libelium, who developed it for use in their SquidBee notes (used for creating sensor networks).

#### Jumper Settings

The Xbee shield has two jumpers (the small removable plastic sleeves that each fit onto two of the three pins labelled Xbee/USB). These determine how the Xbee's serial communication connects to the serial communication between the microcontroller (ATmega8 or ATmega168) and FTDI USB-to-serial chip on the Arduino board.

With the jumpers in the Xbee position (i.e. on the two pins towards the interior of the board), the DOUT pin of the Xbee module is connected to the RX pin of the microcontroller; and DIN is connected to TX. Note that the RX and TX pins of the microcontroller are still connected to the TX and RX pins (respectively) of the FTDI chip - data sent from the microcontroller will be transmitted to the computer via USB as well as being sent wirelessly

by the Xbee module. The microcontroller, however, will only be able to receive data from the Xbee module, not over USB from the computer.

With the jumpers in the USB position (i.e. on the two pins nearest the edge of the board), the DOUT pin the Xbee module is connected to the RX pin of the FTDI chip, and DIN on the Xbee module is connected to the TX pin of the FTDI chip. This means that the Xbee module can communicate directly with the computer - however, this only works if the microcontroller has been removed from the Arduino board. If the microcontroller is left in the Arduino board, it will be able to talk to the computer normally via USB, but neither the computer nor the microcontroller will be able to talk to the Xbee module.

## Networking

The Arduino XBee shield can be used with different XBee modules. The instructions below are for the XBee 802.15.4 modules (sometimes called "Series 1" to distinguish them from the Series 2 modules, although "Series 1" doesn't appear in the official name or product description).

## Addressing

There are multiple parameters that need to be configured correctly for two modules to talk to each other (although with the default settings, all modules should be able to talk to each other). They need to be on the same network, as set by the ID parameter (see "Configuration" below for more details on the parameters). The modules need to be on the same channel, as set by the CH parameter. Finally, a module's destination address (DH and DL parameters) determine which modules on its network and channel will receive the data it transmits. This can happen in a few ways:

- If a module's DH is 0 and its DL is less than 0xFFFF (i.e. 16 bits), data transmitted by that module will be received by any module whose 16-bit address MY parameter equals DL.
- If DH is 0 and DL equals 0xFFFF, the module's transmissions will be received by all modules.
- If DH is non-zero or DL is greater than 0xFFFF, the transmission will only be received by the module whose serial number equals the transmitting module's destination address (i.e. whose SH equals the transmitting module's DH and whose SL equals its DL).

Again, this address matching will only happen between modules on the same network and channel. If two modules are on different networks or channels, they can't communicate regardless of their addresses.

## Configuration

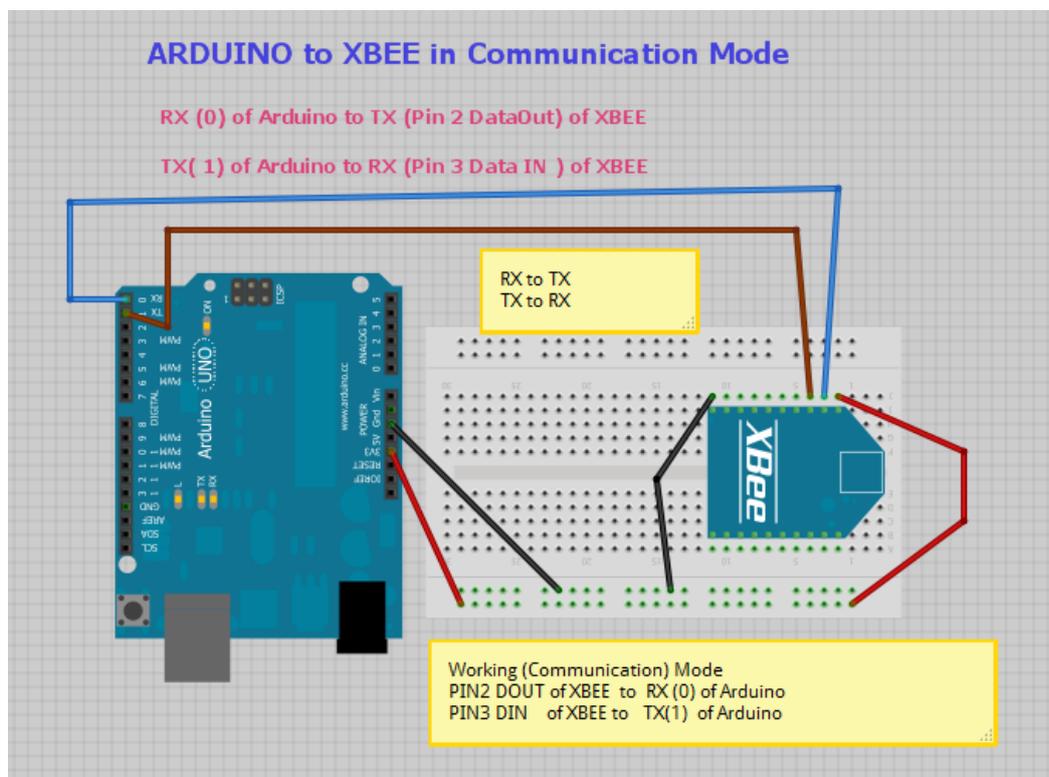
Here are some of the more useful parameters for configuring your Xbee module. For step-by-step instructions on reading and writing them, see the [guide to the Xbee shield](#). Make sure to prepend AT to the parameter name when sending a command to the module (e.g. to read the ID parameter, you should send the command ATID).

Command	Description	Valid Values	Default Value
ID	The network ID of the Xbee module.	0 - 0xFFFF	3332
CH	The channel of the Xbee module.	0x0B - 0x1A	0X0C
SH and SL	The serial number of the Xbee module (SH gives the high 32 bits, SL the low 32 bits). Read-only.	0 - 0xFFFFFFFF (for both SH and SL)	different for each module
MY	The 16-bit address of the module.	0 - 0xFFFF	0
DH and DL	The destination address for wireless communication (DH is the high 32 bits, DL the low 32).	0 - 0xFFFFFFFF (for both DH and DL)	0 (for both DH and DL)
BD	The baud rate used for serial communication with the Arduino board or computer.	0 (1200 bps) 1 (2400 bps) 2 (4800 bps) 3 (9600 bps) 4 (19200 bps) 5 (38400 bps) 6 (57600 bps) 7 (115200 bps)	3 (9600 baud)

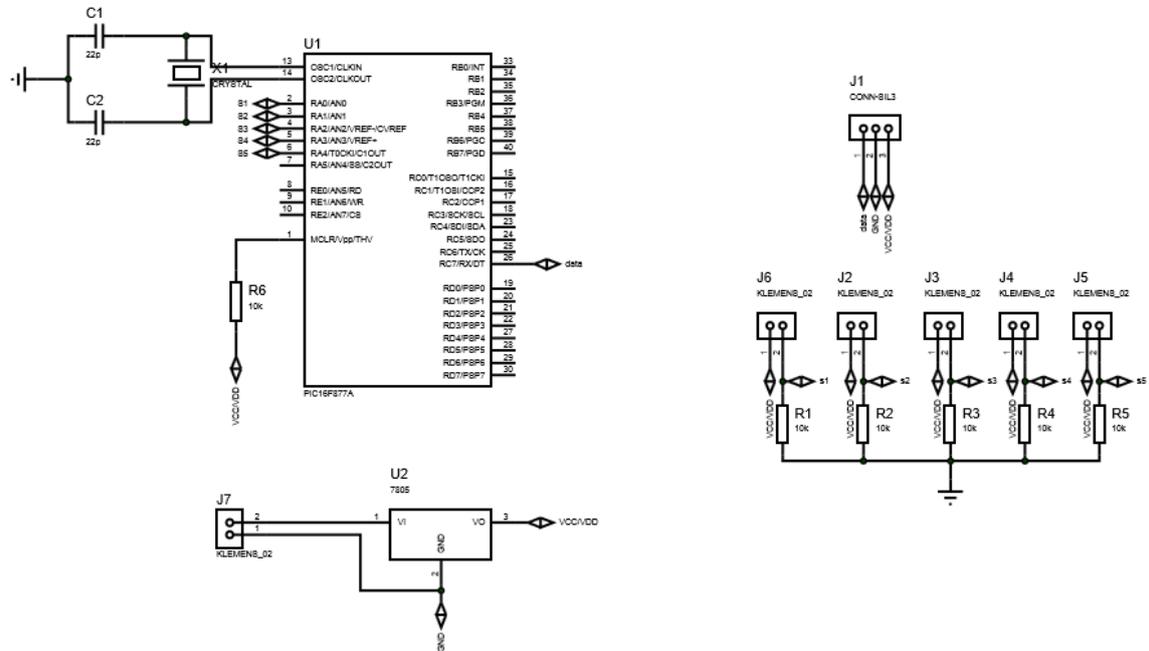
Note: although the valid and default values in the table above are written with a prefix of "0x" (to indicate that they are hexadecimal numbers), the module will not include the "0x" when reporting the value of a parameter, and you should omit it when setting values.

Here are a couple more useful commands for configuring the Xbee module (you'll need to prepend AT to these too).

Command	Description
RE	Restore factory default settings (note that like parameter changes, this is not permanent unless followed by the WRcommand).
WR	Write newly configured parameter values to non-volatile (long-term) storage. Otherwise, they will only last until the module loses power.
CN	Exit command mode now. (If you don't send any commands to the module for a few seconds, command mode will timeout and exit even without a CN command.)



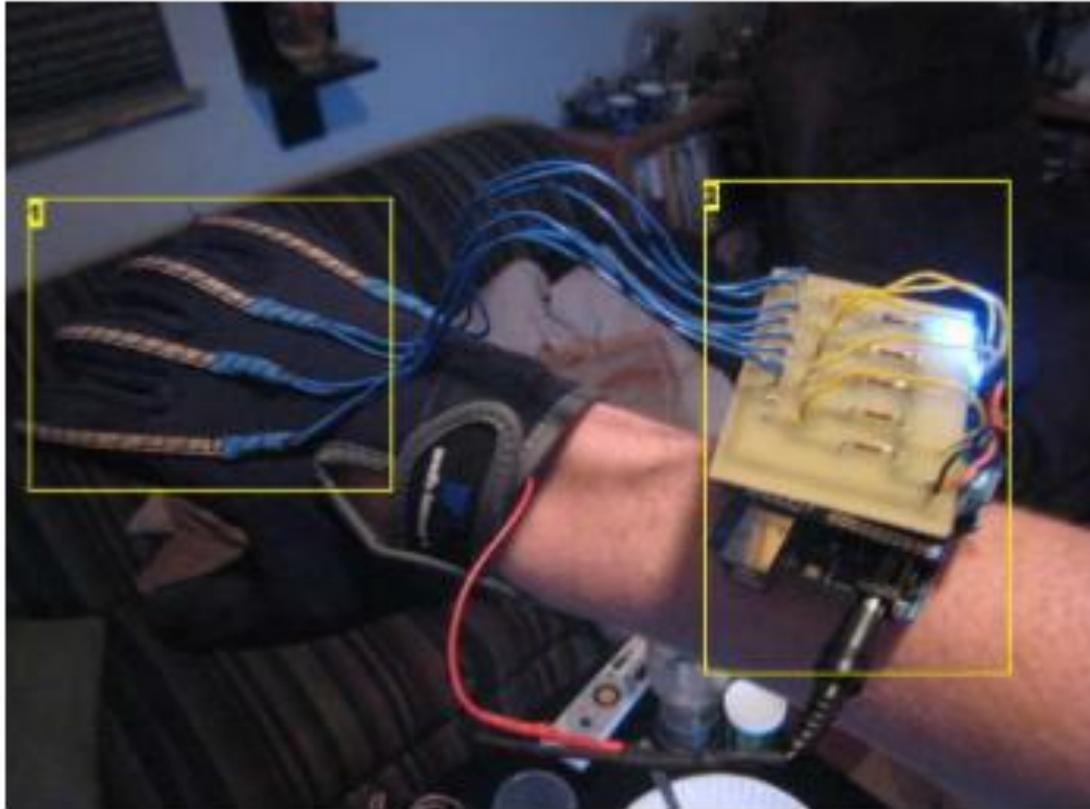
## 4. Circuit Diagram



## 5. Materials

### a. Glove





#### Image Notes

1. Flex Sensors
2. Custom PCB, Xbee, Arduino

### b. Adaptor

These batteries are commonly named 9-volt, and also colloquially named PP3, Radio battery, Square battery, and Japan "006P".

They all have a rectangular shape; the dimensions are height 48.5 mm, length 26.5 mm, width 17.5 mm (or 1.9"x1.0"x0.68"). Both terminals are at one end and their centers are 1/2 inch (12.7 mm) apart.

Inside an alkaline or carbon-zinc 9-volt battery there are six cells, either cylindrical or flat type, connected in series. Some brands use welded tabs internally to attach to the cells, others press foil strips against the ends of the cells.

Rechargeable nickel–cadmium (NiCd) and Nickel-metal hydride (NiMH) batteries have between six and eight 1.2 volt cells. Lithium ion versions typically use two cells (3.7V nominal each). Lithium polymer and low self-discharge NiMH versions can also be found.

Formerly, mercury batteries were made in this size. They had higher capacity than carbon-zinc types, a nominal voltage of 8.4 volts, and very stable voltage output. Once used in photographic and measuring instruments or long-life applications, they are now unavailable due to environmental restrictions.

Type		IEC name <sup>1</sup>	ANSI/NEDA name <sup>2</sup>	Typical capacity (mAh)	Nominal voltage	
Primary (disposable)	Alkaline	6LR61	1604A	565	9	
	Zinc-carbon	6F22	1604D	400		
	Lithium		1604LC	1200		9.6
Rechargeable	NiCd	6KR61	11604	120	7.2	8.4 (some)
	NiMH	6HR61	7.2H5	175-300	7.2	some: <sup>3</sup>
						8.4
	Lithium Polymer			520	7.3	
Lithium-ion Battery			600	8.4		

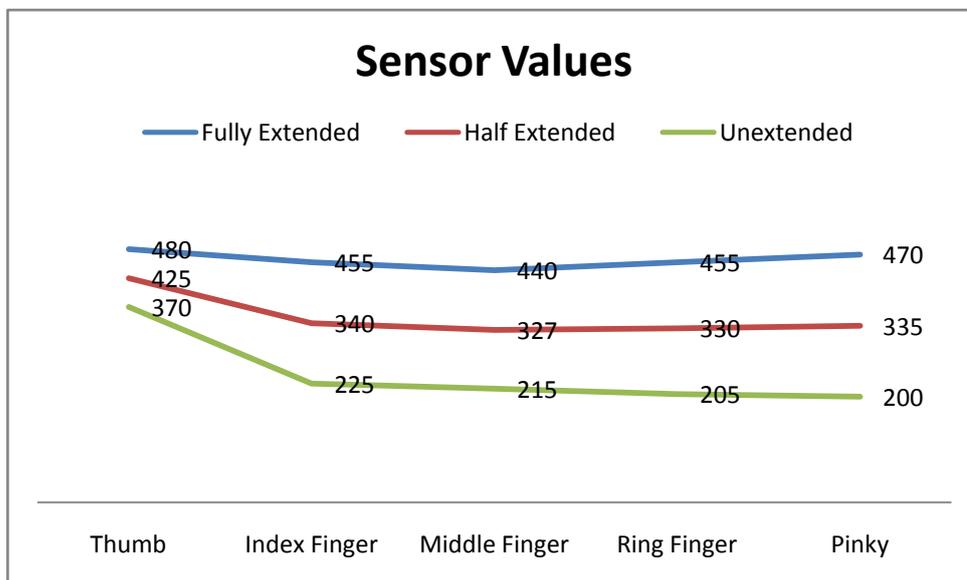
## 6. The Values

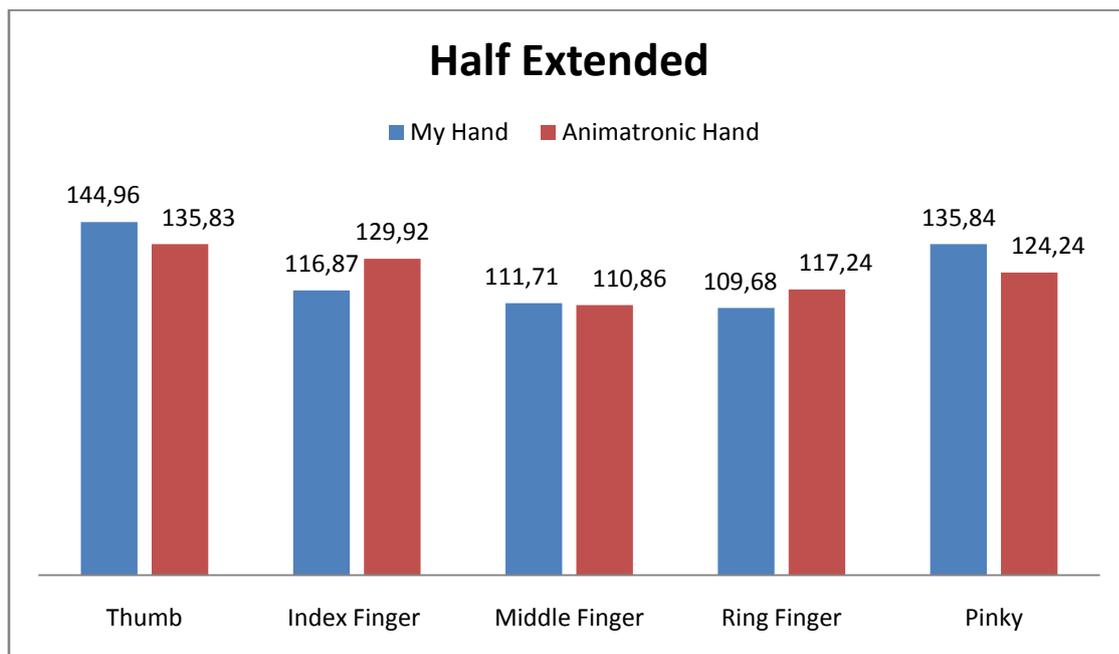
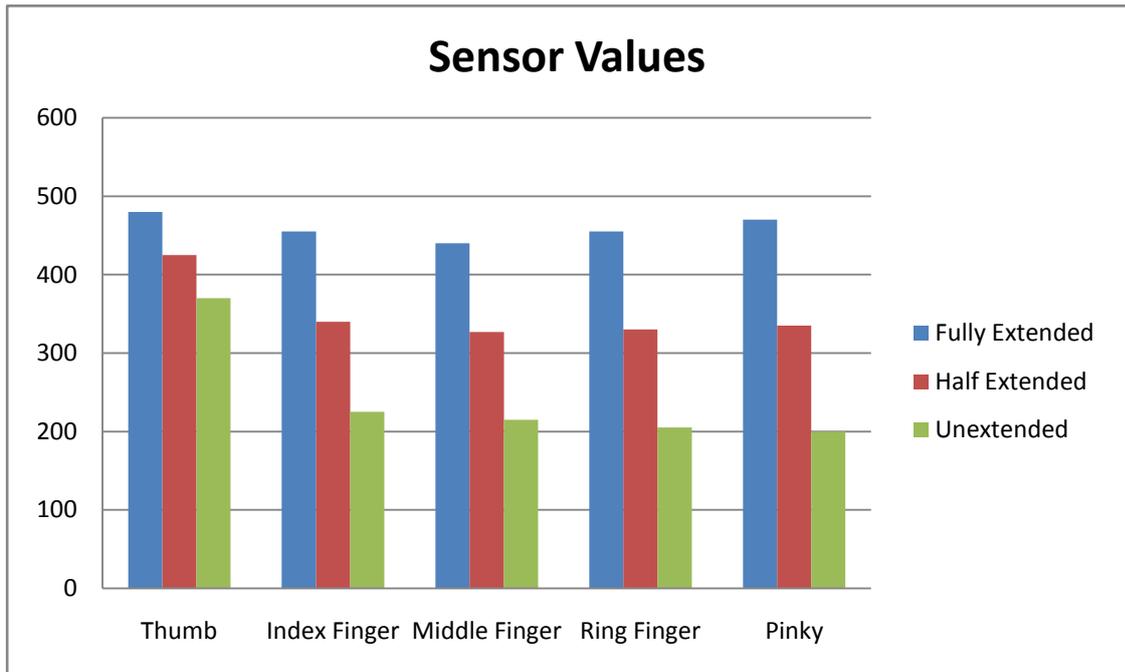
	Thumb	Index Finger	Middle Finger	Ring Finger	Pinky
Fully Extended	480	455	440	455	470
Half Extended	425	340	327	330	335
Unextended	370	225	215	205	200

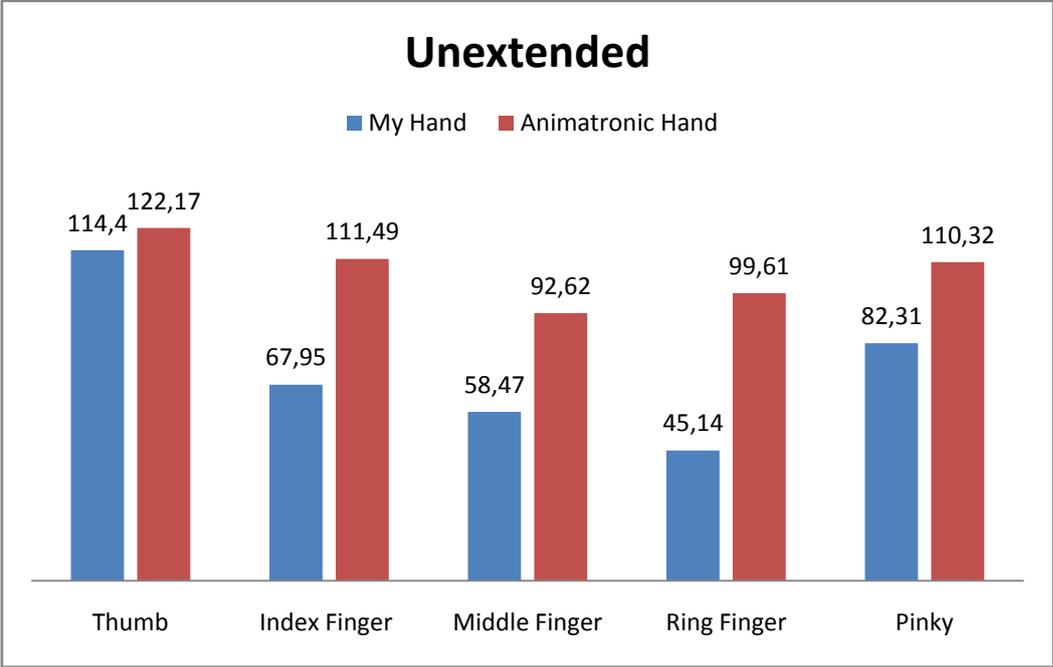
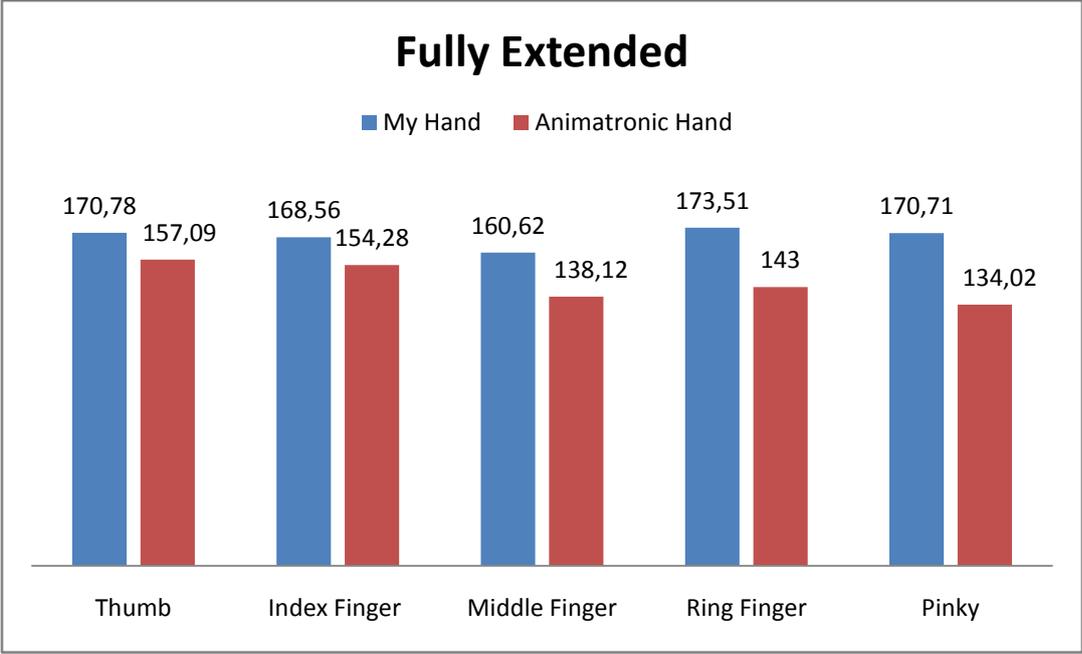
	Thumb	Index Finger	Middle Finger	Ring Finger	Pinky
My Hand	170,78	168,56	160,62	173,51	170,71
Bionic Hand	157,09	154,28	138,12	143	134,02

	Thumb	Index Finger	Middle Finger	Ring Finger	Pinky
My Hand	144,96	116,87	111,71	109,68	135,84
Bionic Hand	135,83	129,92	110,86	117,24	124,24

	Thumb	Index Finger	Middle Finger	Ring Finger	Pinky
My Hand	114,4	67,95	58,47	45,14	82,31
Bionic Hand	122,17	111,49	92,62	99,61	110,32







## B. ARDUINO WIRELESS BIONIC HAND

### 1. Arduino User Guide

#### 1 | Get an Arduino board and USB cable

In this tutorial, we assume you're using an [Arduino Uno](#), [Arduino Duemilanove](#), [Nano](#), [Arduino Mega 2560](#), or [Diecimila](#). If you have another board, read the corresponding page in this getting started guide.

You also need a standard USB cable (A plug to B plug): the kind you would connect to a USB printer, for example. (For the Arduino Nano, you'll need an A to Mini-B cable instead.)



#### 2 | Download the Arduino environment

When the download finishes, unzip the downloaded file. Make sure to preserve the folder structure. Double-click the folder to open it. There should be a few files and sub-folders inside.

#### 3 | Connect the board

The Arduino Uno, Mega, Duemilanove and Arduino Nano automatically draw power from either the USB connection to the computer or an external power supply. If you're using an Arduino Diecimila, you'll need to make sure that the board is configured to draw power from the USB connection. The power source is selected with a jumper, a small piece of plastic that fits onto two of the three pins between the USB and power jacks. Check that it's on the two pins closest to the USB port.

Connect the Arduino board to your computer using the USB cable. The green power LED (labelled PWR) should go on.

#### 4 | Install the drivers

Installing drivers for the [Arduino Uno](#) or [Arduino Mega 2560](#) with Windows 7, Vista, or XP:

- Plug in your board and wait for Windows to begin its driver installation process. After a few moments, the process will fail, despite its best efforts
- Click on the Start Menu, and open up the Control Panel.
- While in the Control Panel, navigate to System and Security. Next, click on System. Once the System window is up, open the Device Manager.
- Look under Ports (COM & LPT). You should see an open port named "Arduino UNO (COMxx)". If there is no COM & LPT section, look under "Other Devices" for "Unknown Device".
- Right click on the "Arduino UNO (COMxx)" port and choose the "Update Driver Software" option.
- Next, choose the "Browse my computer for Driver software" option.
- Finally, navigate to and select the driver file named "arduino.inf", located in the "Drivers" folder of the Arduino Software download (not the "FTDI USB Drivers" sub-directory). If you are using an old version of the IDE (1.0.3 or older), choose the Uno driver file named "Arduino UNO.inf"
- Windows will finish up the driver installation from there.

Installing drivers for the [Arduino Duemilanove](#), [Nano](#), or [Diecimila](#) with Windows7, Vista, or XP:

When you connect the board, Windows should initiate the driver installation process (if you haven't used the computer with an Arduino board before).

On Windows Vista, the driver should be automatically downloaded and installed. (Really, it works!)

On Windows XP, the Add New Hardware wizard will open:

- When asked Can Windows connect to Windows Update to search for software? select No, not this time. Click next.
- Select Install from a list or specified location (Advanced) and click next.
- Make sure that Search for the best driver in these locations is checked; uncheck Search removable media; check Include this location in the search and browse to the drivers/FTDI USB Drivers directory of the Arduino distribution. Click next.
- The wizard will search for the driver and then tell you that a "USB Serial Converter" was found. Click finish.
- The new hardware wizard will appear again. Go through the same steps and select the same options and location to search. This time, a "USB Serial Port" will be found.

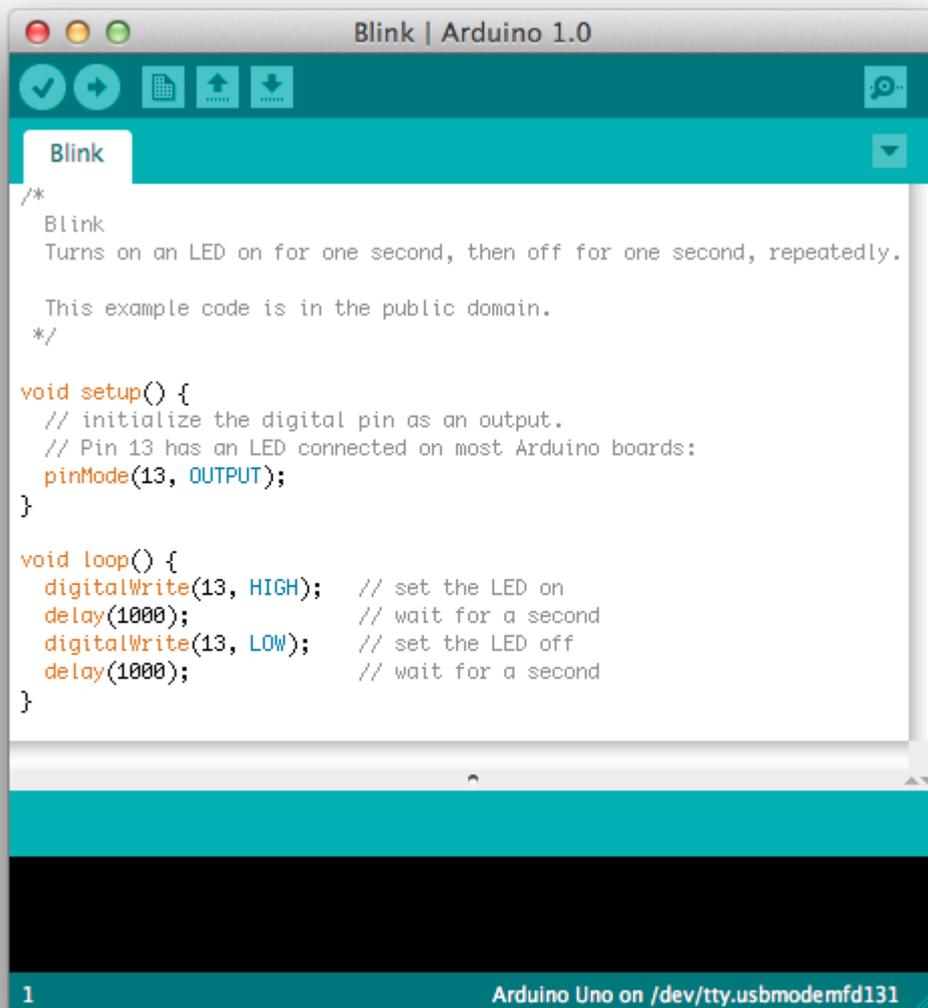
You can check that the drivers have been installed by opening the Windows Device Manager (in the Hardware tab of System control panel). Look for a "USB Serial Port" in the Ports section; that's the Arduino board.

## 5 | Launch the Arduino application

Double-click the Arduino application. (Note: if the Arduino software loads in the wrong language, you can change it in the preferences dialog. See [the environment page](#) for details.)

## 6 | Open the blink example

Open the LED blink example sketch: File > Examples > 1.Basics > Blink.

A screenshot of the Arduino IDE interface. The window title is "Blink | Arduino 1.0". The top toolbar contains icons for a checkmark, a play button, a document, an upload button, a download button, and a refresh button. Below the toolbar is a teal header bar with the word "Blink" and a dropdown arrow. The main area is a white text editor containing the following code:

```
/*
  Blink
  Turns on an LED on for one second, then off for one second, repeatedly.

  This example code is in the public domain.
  */

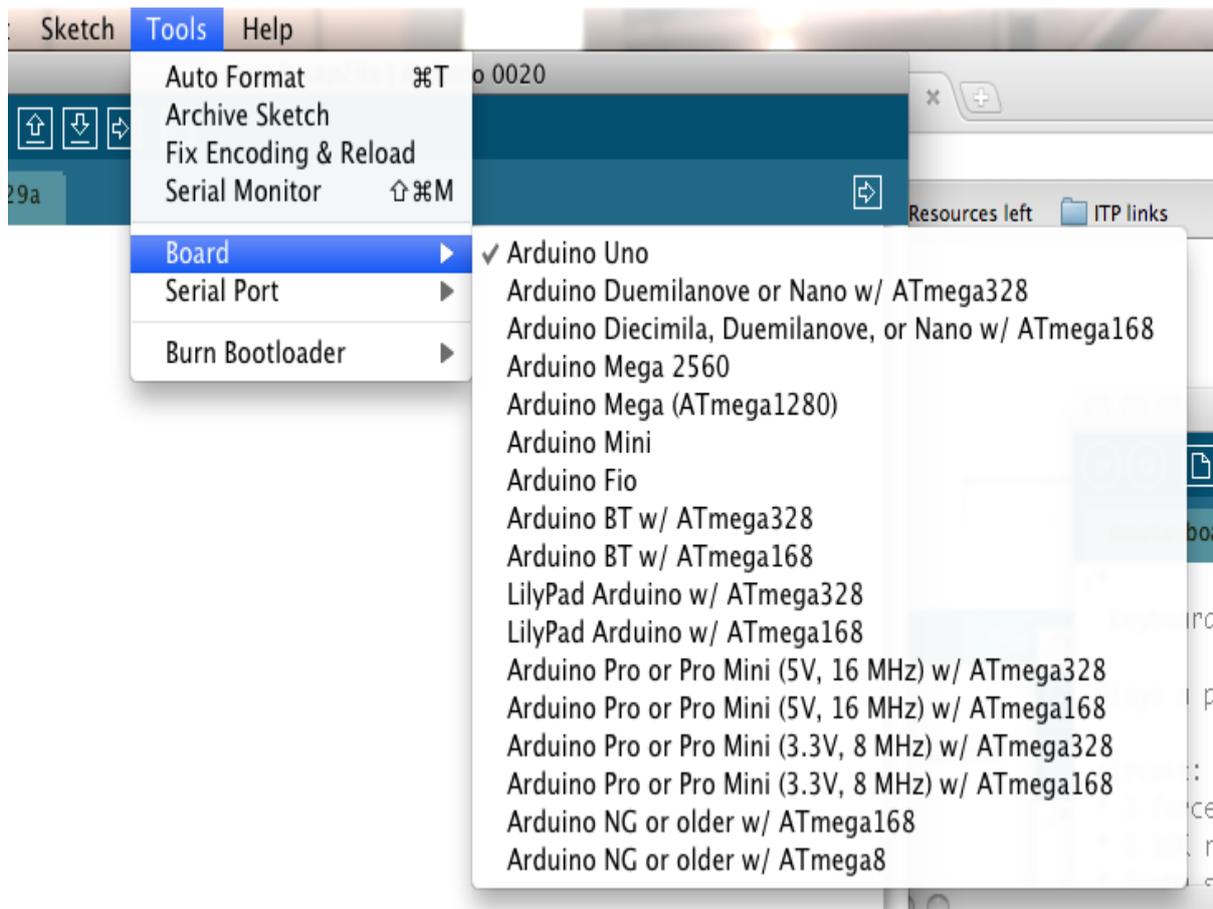
void setup() {
  // initialize the digital pin as an output.
  // Pin 13 has an LED connected on most Arduino boards:
  pinMode(13, OUTPUT);
}

void loop() {
  digitalWrite(13, HIGH); // set the LED on
  delay(1000);           // wait for a second
  digitalWrite(13, LOW); // set the LED off
  delay(1000);           // wait for a second
}
```

The bottom of the IDE shows a black status bar with the text "1" on the left and "Arduino Uno on /dev/tty.usbmodemfd131" on the right.

## 7 | Select your board

You'll need to select the entry in the Tools > Board menu that corresponds to your Arduino.



### Selecting an Arduino Uno

For Duemilanove Arduino boards with an ATmega328 (check the text on the chip on the board), select Arduino Duemilanove or Nano w/ ATmega328. Previously, Arduino boards came with an ATmega168; for those, select Arduino Diecimila, Duemilanove, or Nano w/ ATmega168.

### 8 | Select your serial port

Select the serial device of the Arduino board from the Tools | Serial Port menu. This is likely to be COM3 or higher (COM1 and COM2 are usually reserved for hardware serial ports). To find out, you can disconnect your Arduino board and re-open the menu; the entry that disappears should be the Arduino board. Reconnect the board and select that serial port.

### 9 | Upload the program

Now, simply click the "Upload" button in the environment. Wait a few seconds - you should see the RX and TX leds on the board flashing. If the upload is successful, the message "Done uploading." will appear in the status bar. (Note: If you have an Arduino Mini, NG, or other board, you'll need to physically present the reset button on the board immediately before pressing the upload button.)



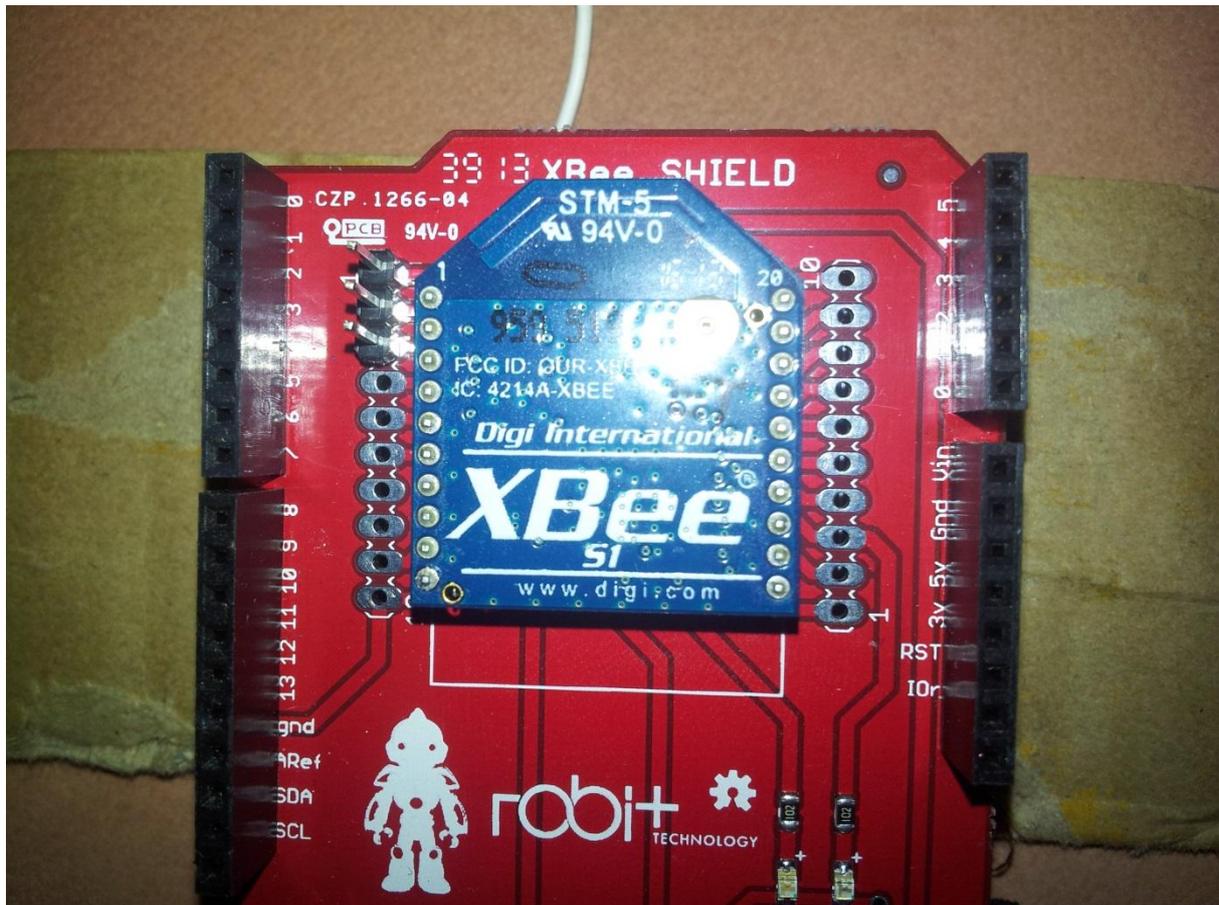
A few seconds after the upload finishes, you should see the pin 13 (L) LED on the board start to blink (in orange). If it does, congratulations! You've gotten Arduino up-and-running. If you have problems, please see the troubleshooting suggestions. You might also want to look at:

- the examples for using various sensors and actuators
- the reference for the Arduino language

The text of the Arduino getting started guide is licensed under a Creative Commons Attribution-ShareAlike 3.0 License. Code samples in the guide are released into the public domain.



## 2. XBee Wireless Module For Robotic Hand



- No configuration needed for out-of-the-box RF communications
- Common XBee footprint for a variety of RF modules
- Fast 250 kbps RF data rate to the end node
- 2.4 GHz for worldwide deployment
- Sleep modes supported for extended battery life

## 3. Servo Motors

The **TP SG90** is similar in size and weight to the Hitec HS-55, and is a good choice for most park flyers and helicopters. Hobbyists from around the world has used the SG90 on famous planes like GWS Slow Stick, E-Flite Airplanes, Great Planes, Thunder Tiger, Align, EDF jets and more. If you are looking for a servo that won't break your arm or leg, this is the perfect choice for you!

The TP SG90 servo weighs 0.32 ounces (9.0 grams). Total weight with wire and connector is 0.37 ounces (10.6 grams).

The TP SG90 has the universal "S" type connector that fits most receivers, including Futaba, JR, GWS, Cirrus, Blue Bird, Blue Arrow, Corona, Berg and Hitec.

The wire colors are **Red = Battery(+)** **Brown = Battery(-)** **Orange = Signal**

### **TP SG90 Specifications:**

Dimensions (L x W x H) = 0.86 x 0.45 x 1.0 inch (22.0 x 11.5 x 27 mm)

Weight = 0.32 ounces (9 grams)

Weight with wire and connector = 0.37 ounce (10.6 grams)

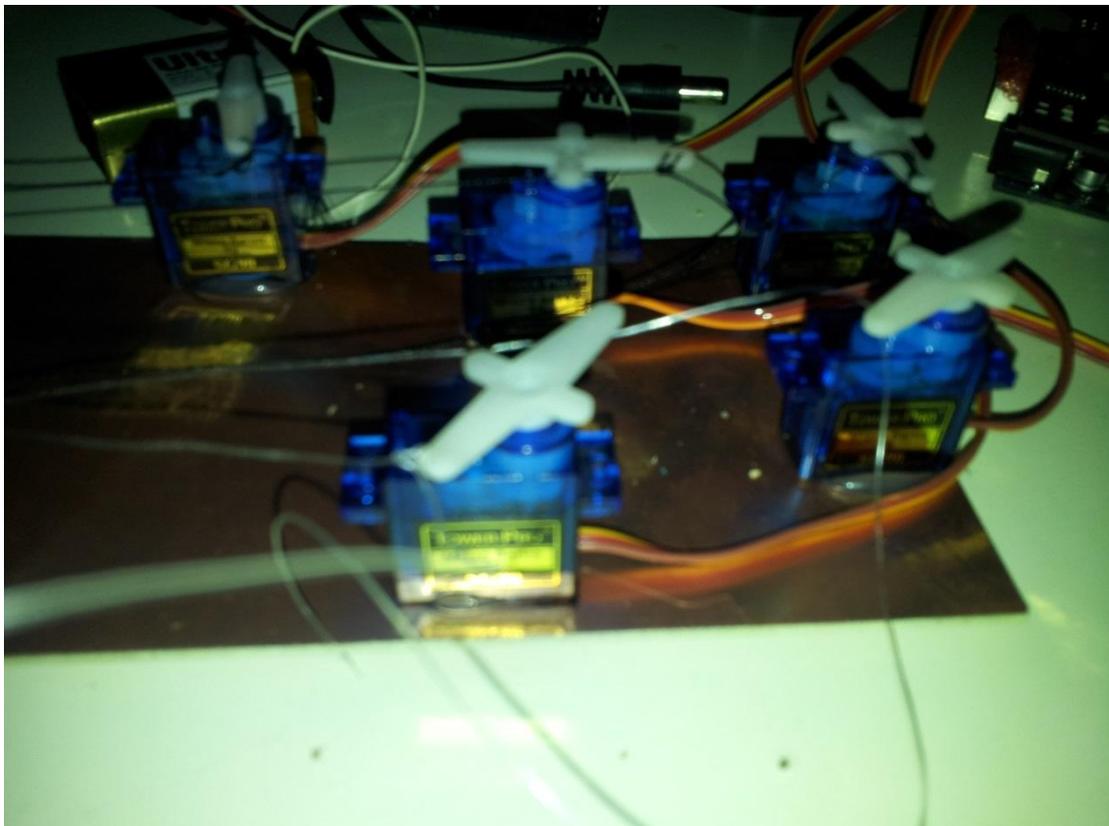
Stall Torque at 4.8 volts = 16.7 oz/in (1.2 kg/cm)

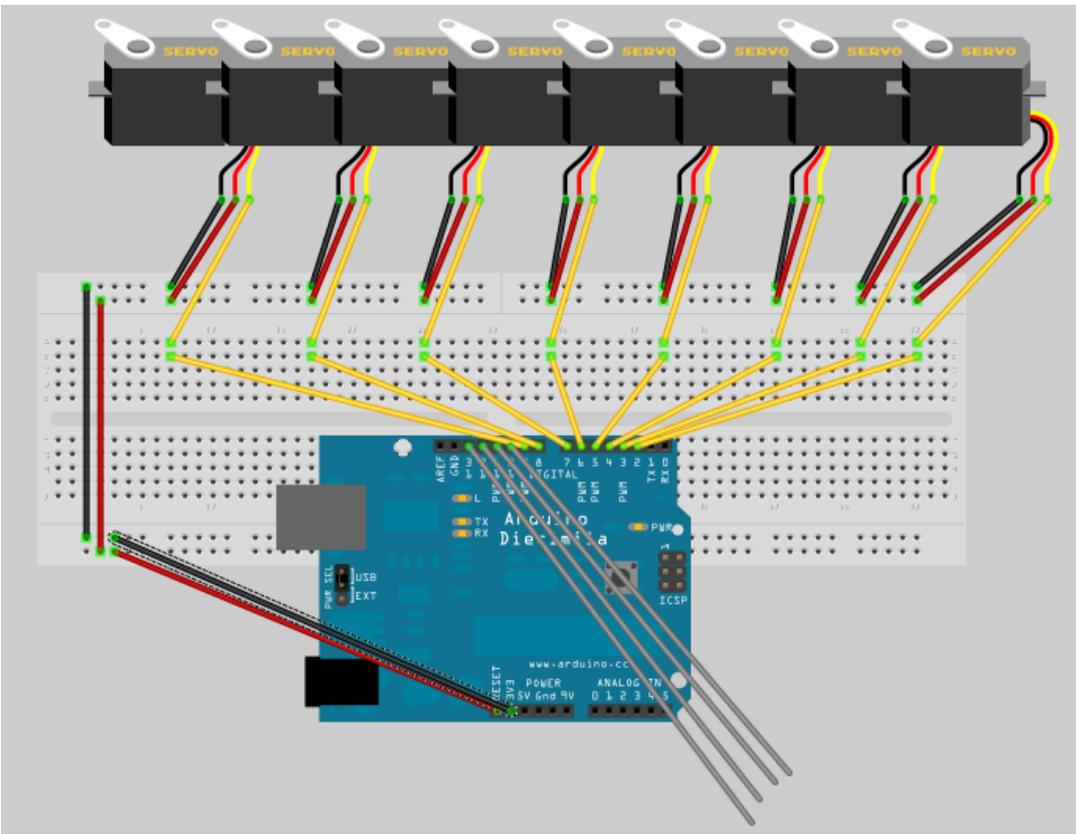
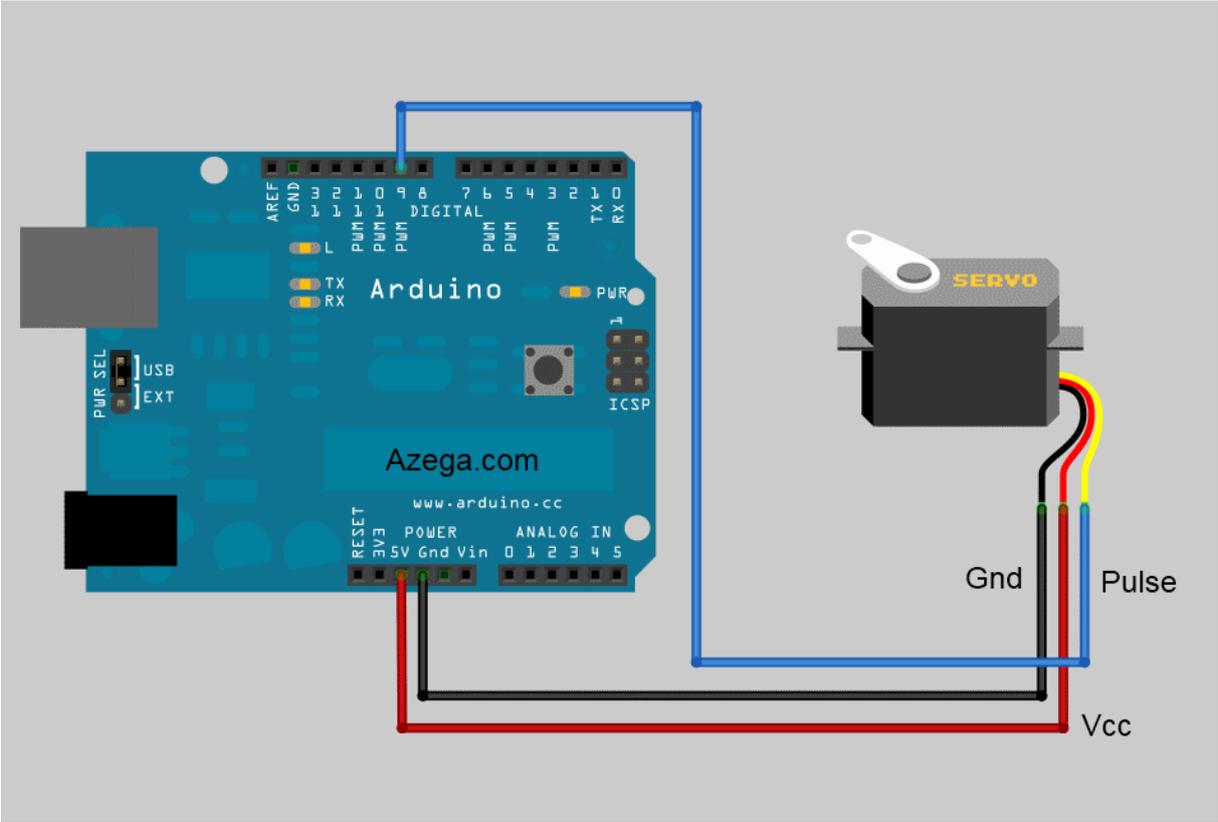
Operating Voltage = 4.0 to 7.2 volts

Operating Speed at 4.8 volts (no load) = 0.12 sec/ 60 degrees

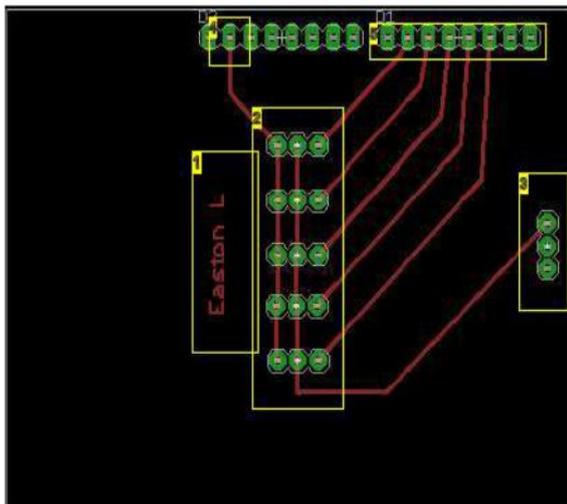
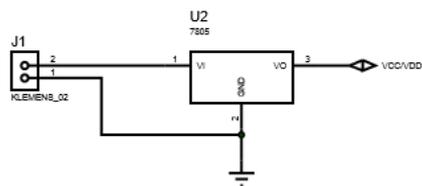
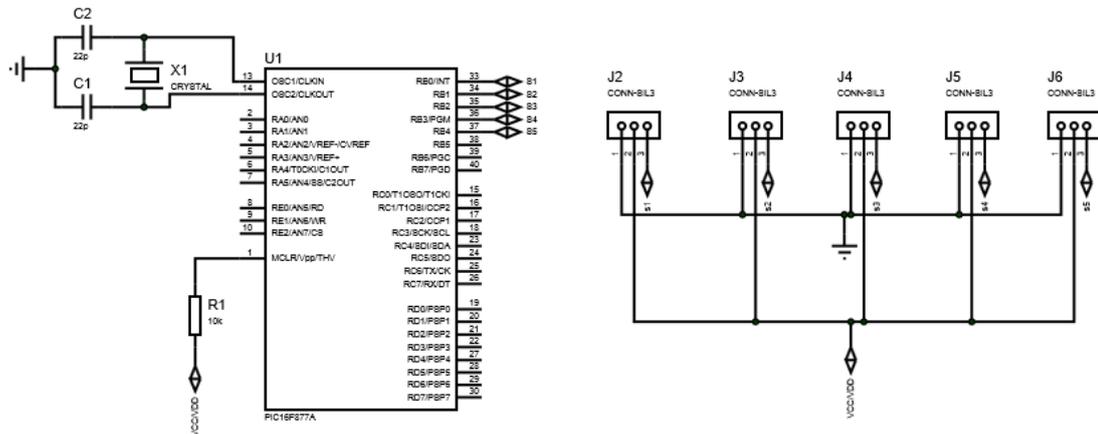
Connector Wire Length = 9.75 inches (248 mm)

Universal "S" type connector fits most receivers

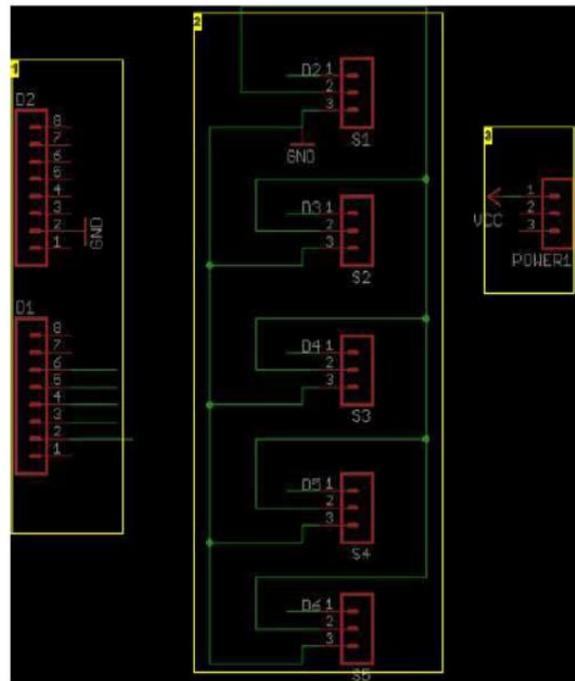




## 4. Circuit Diagram For Receiver Part



- Image Notes**
1. This needs to be reversed
  2. Servos!
  3. Power (+)
  4. Power (ground)
  5. Digital Outputs



- Image Notes**
1. Arduino Pins
  2. Servo
  3. Arduino Power

## 5. Code

The very first thing we want to do is our shield or Xbee s are unplugged from the Arduino.Or make sure the correct jumpers are in the right place .We have written this code:

```
int Finger1 = 0;
int Finger2 = 1;
int Finger3 = 2; int Finger4 = 3;
int Finger5 = 4;
void setup()
{
Serial.begin(9600);
}
void loop()
{ byte servoValue1;
byte servoValue2;
byte servoValue3;
byte servoValue4;
byte servoValue5;
int FingerV1 = analogRead(Finger1);
int FingerV2 = analogRead(Finger2);
int FingerV3 = analogRead(Finger3);
int FingerV4 = analogRead(Finger4);
int FingerV5 = analogRead(Finger5);
if (FingerV1 < 200) FingerV1 = 200;
else if (FingerV1 > 460) FingerV1 = 460;
if (FingerV2 < 200) FingerV2 = 200;
else if (FingerV2 > 460) FingerV2 = 460;
```

```

if (FingerV3 < 200) FingerV3 = 200;
else if (FingerV3 > 460) FingerV3 = 460;
if (FingerV4 < 200) FingerV4 = 200;
else if (FingerV4 > 460) FingerV4 = 460;
if (FingerV5 < 200) FingerV5 = 200;
else if (FingerV5 > 460) FingerV5 = 460;
byte servoVal1 = map(FingerV1,460, 200, 255, 0);
byte servoVal2 = map(FingerV2,460, 200, 255, 0);
byte servoVal3 = map(FingerV3,460, 200, 255, 0);
byte servoVal4 = map(FingerV4,460, 200, 255, 0);
byte servoVal5 = map(FingerV5,460, 200, 255, 0);
Serial.print(servoVal1);
Serial.print(servoVal2);
Serial.print(servoVal3);
Serial.print(servoVal4);
Serial.print(servoVal5);
delay(100);
}

```

Here is the receiving:

```

#include

Servo myservo1; // create servo object to control a servo
Servo myservo2;
Servo myservo3;
Servo myservo4;
Servo myservo5;

void setup()
{

```

```
Serial.begin(9600);

myservo1.attach(2); // attaches the servo on pin 9 to the servo object
myservo2.attach(3);
myservo3.attach(4);
myservo4.attach(5);
myservo5.attach(6);
}

void loop()
{
  if(Serial.available() >=5)
  {
    byte servoAng1 = Serial.read();
    byte servoAng2 = Serial.read();
    byte servoAng3 = Serial.read();
    byte servoAng4 = Serial.read();
    byte servoAng5 = Serial.read();

    // Send the servo to the position read... (note: you get to make this happen)
    myservo1.write(servoAng1);
    myservo2.write(servoAng2);
    myservo3.write(servoAng3);
    myservo4.write(servoAng4);
    myservo5.write(servoAng5);
  }
}
```

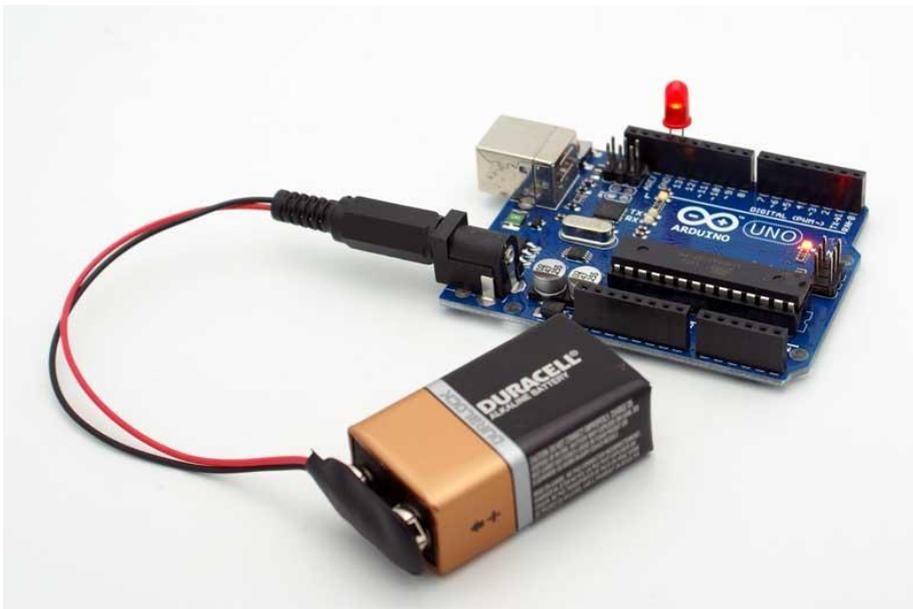
## 6. Materials For Bionic Part

### a. Adaptor

#### i. 5V for Servo Motors

- AC ADAPTOR, 5V, 1.5A REGULATED
- Output Connector: 2.1mm x 5.5mm x 12mm
- Output Power Max: 7.5W
- Power Supply Output Type: Fixed
- External Width: 50mm
- External Depth: 26.5mm
- Approval Bodies: CB, CE
- Efficiency: 63%
- Height: 64mm
- No. of Outputs: 1
- Output Current: 1.5A
- Output Voltage: 5V
- Power Rating: 7.5W
- Power Supply Type: Plug-In External
- Supply Frequency Max: 63Hz
- Supply Frequency Min: 47Hz
- Supply Voltage AC Max: 264V
- Supply Voltage AC Min: 90V
- Weight: 0.13kg

#### ii. 9V For Arduino



## b. Finger



- 1-We researched hands and found a diagram where the joints are
- 2-We cut the joints with the exacto knife
- 3-We put all the fingers without the thumb
- 4-We taped the fingers securely and put the thumb over those so it would have human like flex
- 5-We taped the servos together filling spaces with Styrofoam
- 6-We added all 5 servos to the hand with tape
- 7-We built the circuit on a breadboard with just delivering power the servos and having the control wires into the digital input on the arduino
- 8-We ran fishing tackle from the finger tip through the tube and anchored it onto the servo.

## C. MATERIAL LIST

<b>Component List</b>						
Name	Capc/Freq	Voltage	Current	Resistance	Length	Weight
Flex Sensors				45 k - 120 k	4.5 inch	
Servo motor (MG 90)		4.8-6 V				13.4 gram
Adaptor		5V	10 Amp			
<b>Reciever Circuit Material</b>						
18F452		9v				
LM2575	52KHz	9v	1Amp			
Crystal	20MHz					
Reciever Module		2.5v-5.5v	3-5Amp			
Capacitor	22pf					
<b>Transmitter Circuit</b>						
Transmitter Module		2.5v-5v	3-5Amp			
18F452		9v				
Crystal	20MHz					
LM2575	52KHz	9v				
Capacitor	22pf					