

Muscle Wires® Moving Hand Kit

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Muscle Wires® Moving Hand Kit



Human



DK-109

Monster



DK-103

Robot



DK-107

This Moving Hand Kit demonstrates the amazing capabilities of Muscle Wires® that actually shorten in length when powered!

- *Silent, realistic motion.*
- *Variable Movement cycle*
- *Easy assembly*
- *An excellent introduction to electronics, mechanics, and SMA's!*



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1.0 Introduction

We hope you enjoy this kit; it is one of our most advanced. It demonstrates some capabilities of bipolar integrated circuits, of Flexinol® shape memory alloy actuator wire, and of a flexure. When you are done, you'll have a very interesting hand that moves realistically and is completely silent.

You do not have to have any special experience or training to put together this kit. It will help if you know what a resistor or printed circuit board is, but if you don't that's all right. If you have not soldered before, we suggest you go to www.musclewires.com and look at the "How to Solder" document on the Support page.

2.0 What you will need:

- **Soldering iron.** Intended for electronics assembly with a relatively fine tip.
- **Solder.** It will be easiest if it has rosin flux core. Finer, i.e. smaller, diameter is better.
- **Wire strippers.** With which you can strip #30 gauge wire.
- **Wire cutters.** The small type that have an angled head, intended for electronics use, is best. You will need to cut off the leads after soldering.
- **Glue.** We recommend a fairly thick glue that takes a few minutes to set. Super Glue, Silicones, Goop®, and epoxy should all work
- **Tape.** Normal clear household tape, like you use to tape two pieces of paper together, is fine.
- **A weight of some kind.** This keeps the hand from falling over from normal movement in the room. Something the weight of a couple quarters is fine.
- **Scissors.** Something that will cut .010 inch/.25 mm PET film.
- **Power Source.** 4AA batteries, or an AC adapter (6.0 Volts at 300 milliamp).
- **Multimeter.** (Recommended) This is useful to test the circuit as you assemble it to ensure that everything is working as intended. Anything that can measure voltage will do.

Check out Additional Products from MuscleWires.com:

Use your Insight to dream up ways to utilize these products with your Moving Hand Circuit!



Flexinol® Switch Cover (# DA-416)

This device shows how easily and versatile Flexinol® actuator wires can be to solve problems! Flexinol® added to a simple switch can give you: a simple relay, an electromechanical oscillator, a circuit protection device, or a hot cutoff!



Flexinol® Electrostem™ II Valve (# DA-412)

In this application, Flexinol® is added to a Schraeder valve core. With the addition of the actuator wire, the valve can very gradually open or close to produce proportionally controlled air flow! Comes with standalone electronics.



Flexinol® Latchbox (# DA-419)

Once of the best uses for Flexinol® is in electronic locks. This Latchbox is a low cost example. Flexinol® contracts when heated electrically and frees the latch. This demonstration unit is only one example of the possibilities of Flexinol® use in latches. What can you dream up?



Flexinol® Bendsoft™ (# DA-414)

The Bendsoft™ works by allowing the Flexinol® actuator wire to contract along one side of a non-compressing strip of plastic. Not only does this showcase the technology, it can also be used for micro-miniature animation in small animated figurines and other devices!

*Did you invent a brilliant use for our Muscle Wires® products?
Share your ideas with us for possible recognition on our website!*

7.0 Advanced Tuning

There are several things you can do to further customize your hand.

- You can change the hand. We have several different hands available, or you can make your own.
- You can change the timing to make the hand move slower or faster. If you do a web search for “555 Timer” you will have no difficulty getting detailed instructions. Be careful though. If you keep the heat on too long you can overheat the wire. That will reduce the life of the wire, and if overdone you can cut through the PET film guides. As a general guideline, if the finger begins opening immediately when the power switches to the next position, it probably has not been overheated. If it stays closed for a second or two that means the wire was probably overdriven.
- You can also use the Muscle Wires® Moving Hands Kit Circuit Board to control up to 8 separate devices by utilizing the electrical signals generated at F1-F8. You can replace the Flexinol® actuator wire with any device that uses has similar power requirements (600mA & 3.8 V) A simple web search for PN2222A NPN Transistor will give specifications for the maximum current the transistor can provide.
- You can use the electrical signal from F1-F8 to operate a relay such as the Flexinol® Switch Cover Kit (DA-416). The relay can then be used to operate a device with much greater power requirements by utilizing a separate power source. The signal will activate the relay and make an electrical connection to the new device and the auxiliary power supply.
- You can use JP2 as a reset select to decrease the counter from an 8 down to 1 by inverting OΩ resistor from the labeled number to the reset select outputs can also be paired using a OΩ resistor in R22 to R28

3.0 Included in This Kit

- Three pieces cut from polyester (PET) film. These are the hand and two strips of wire retainers.
- The stand and the wrist brace.
- Printed Circuit Board (PCB)
- Eight pin Dual Inline Package (DIP) socket. This is the black plastic device with 8 metal pins and nothing else
- 16 pin (DIP) socket
- U1: 4022 counter IC
- U2: 555 Timer Integrated Circuit (IC)
- C1: 0.1 microfarad Capacitor
- C3: 0.47 microfarad tantalum Capacitor
- R1 through R8: 220 Ohm Resistors (red red brown gold)
- R9: 1.5M Ω (brown green green gold)
- R10: 100 K Ω (brown black yellow gold)
- R13: 1K Ω resistor (brown black red gold)
- Q1 through Q8: 2222 NPN transistors. These are black with three leads.
- D1 through D8: LED's
- Five Flexinol® wires crimped to gray electrical wire.
- Battery Holder for 4AA batteries
- Mini plug
- J1: Mini jack
- Blue wire to be used for option jumpers
- D9: IN4001 Diode
- F1 through F8: 5.1 Ω, 1/2W Resistor (green brown gold gold)
- R14 through R21: 1K Ω resistor (brown black red gold)
- JP 1.1: 0 Ω resistor (Single black stripe)

4.0 How It Works

Electrical

This circuit is based on two integrated circuits (IC's)- the 555 timer and the 4022 counter. The 555 can serve several different functions, but we are using it as a bistable vibrator. Based on a timer period set by the values of the capacitor C3 and the resistors R9 and R10, the 555 sends a pulse to pin 3. By “Pulse” we mean that the output is connected to ground. This is called “Logic Low”. In our case we chose these values to give us a pulse approximately every second.

The 4022 integrated circuit is a counter circuit. It has an input pin, and each time the voltage on this pin is connected to ground for a brief fraction of a second, it adds one to whatever number it already had. It displays its current value by setting one of its output pins to logic low, and the others are held at logic high. When it reaches the highest number it can hold, it resets to zero and continues counting. This type of circuit is commonly available as an “8” counter, as a “10” counter, and as a “16” counter. These are called octal, decimal, and hexadecimal or hex counters, based on the Latin for eight, ten, and sixteen. If you connect the output from one decimal counter to the input of another, you can count to 100, and so on. The 4022 is an octal counter.



Fig. 4.1: PCB populated with supplied components.

We connect the output of the 555 to the input of the 4022, and we connect each of the eight outputs of the 4022 to drive one of the output sections. We cannot connect them directly. The 4022 handles only very small currents, and if we were to send enough current through it to power the Flexinol® we would quickly damage the IC. Instead we connect the outputs from the 4022 to an NPN transistor (in our case the 2222). The transistor has three terminals, called emitter, base, and collector. It is like a remote switch, so when the base lead on the NPN transistor is connected, the transistor allows current to flow from the collector to the emitter. When the base lead is not connected, no current is allowed to flow.

6.2.4. If there is no slipping, glue the palm side of the wire. You want there to be a little tension in the wire, so the fingertips are curved by around quarter of an inch/ one centimeter or a bit more. To maintain the tension while the glue is drying we recommend you use some kind of clamp like binder clips, or super glue hardener.

6.2.5. Finally, tape the wires onto the palm area of the hand. This reduces the strain on the wire connections.

7.0 Using Your Kit

7.1. Slide the slots in the stand into the slots in the hand and the wrist brace as shown. (See Figure 7.3)

7.1.1. Align the slots on the hands and wrist (Parts A and B) as shown in Figure 7.1 and slide them together. The bend in Part B should face toward the front of the hand. This forms the base on which the hand will sit.

7.1.2. Take Part C and insert it between Parts A and B as shown in Figure 7.2. It may be difficult to align both of the slots at the same time, but by doing one side and then the other it will go together. Part C puts a bend into the palm of the hand and adds stiffness to support the entire assembly.

7.1.3. You can now tape a weight the size of a few quarters to the wrist in order to add stability to the hand.



Fig. 7.1



Fig. 7.2

7.2. When the parts are together, tape or glue them so they don't shift. If you tape or glue some small weights to the base of the hand it will be more stable.

7.3. Connect one lead wire from each finger to the 5.1 Ω resistor. Then attach the remaining end of the finger and the other side of 5.1 Ω resistor to the pads labeled F1+ through F8+ and F1- through F8-. The + and - pads of the same number should be connected through the finger and resistor in series, but which end (resistor or wire) goes to which of the + and - pads does not matter.

There are eight steps and five fingers, so there will be pauses. It's simplest to connect the thumb to 1, pointing finger to 2, index finger to 3, ring finger to 4, and little finger to 5. The hand will close the fingers in succession and then wait for a couple seconds before repeating. Once you understand this you can change the sequence simply by changing the connections by connecting the fingers differently.



Fig. 7.3

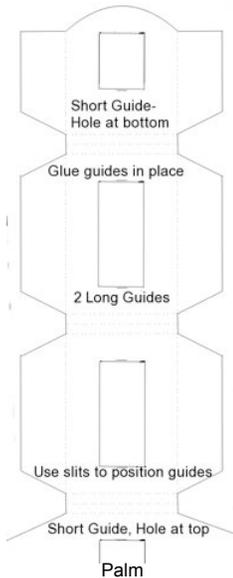


Fig. 6.3

- 6.1.2. Then fold up the three sides of the shorter guides. These are essentially half of the longer ones.
- 6.1.3. Now you glue these down, two long and two short for each finger. See the Figure 6.3 for how it should look. We have marked the hand for where the guides should go.

You can use instant adhesives, although some of the guides may pop off initially. Re-glue them a time or two and they'll stick fine. You may prefer a slower-setting adhesive. Epoxy is a good choice, but there are many common household adhesives that will work.

6.2. Inserting and Gluing the Wires

- 6.2.1. Once the guides are solidly dry you thread the Flexinol® wire through the holes in the ends of the guides. You need to be sure you haven't missed any guides as in Figure 6.4. If you insert one of the wires through only five of the six guides, that finger will not work, and once the wires are glued in place they generally cannot be removed without damaging them.

Note: When unpackaging, take care not to kink, knot or tangle the wires.

- 6.2.2. Make sure the wire is centered between the end guides, then glue the end of the wire on the **Tip** of the finger first. Let that glue harden according to the glue's instructions- it is important that this end not slip when you do the next step.

- 6.2.3. When the fingertip side is hardened, test these by pulling, not too hard, on the palm side of the wire.

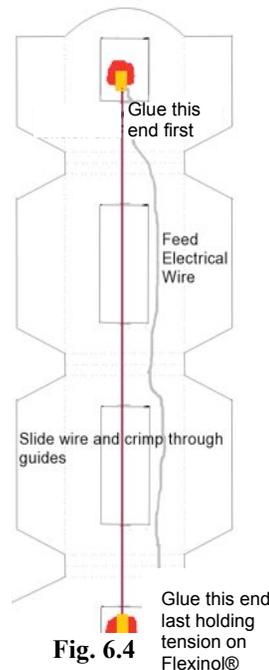


Fig. 6.4

4.0 How It Works (cont'd)

Electrical

The emitter of each transistor is connected to:

- A resistor, which in turn is connected to an LED, which is connected to ground. This allows you to see which output is on at any given moment. The resistor limits the current, because small LED's burn out if you drive more than a few milliamps through them
- A header pin which can be used to drive the Flexinol® wire.

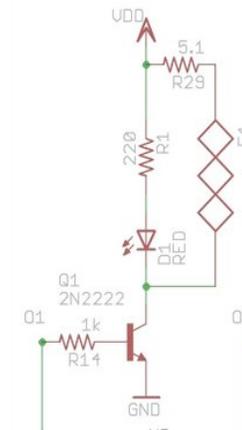


Fig. 4.2: Schematic of transistor, Flexinol®, resistor and LED.

Mechanical



Fig. 4.3: Relaxed state of Flexinol® mechanism.

As the finger bends, the wire lifts away from the joint, the moment arm increases, and the force in the wire reduces.

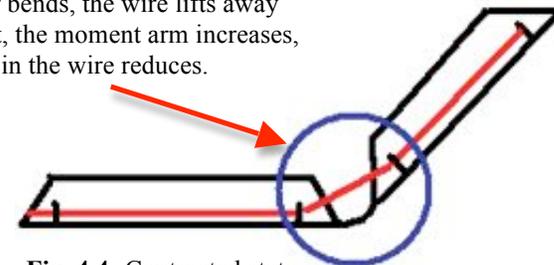


Fig. 4.4: Contracted state of Flexinol® mechanism.

4.0 How It Works (Cont'd)

Electrical

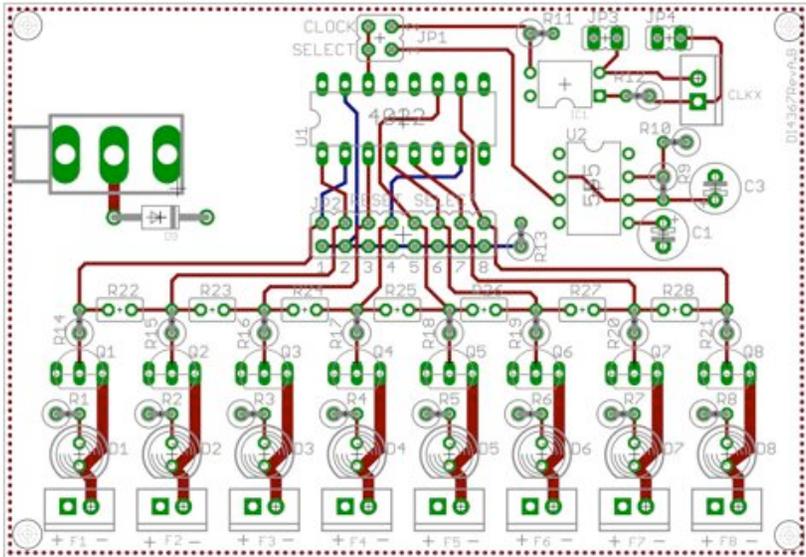


Fig. 4.5: Blueprint of PCB

If you look at the circuit board you see that the bottom hole of D1 has a connection trace going to the pad labeled F1-. This hole is for the negative wire from the LED.



Fig. 5.5: LED

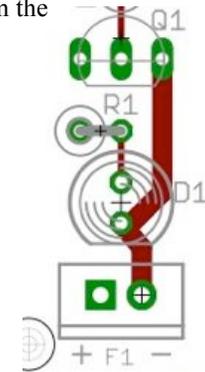


Fig. 5.6: Connecting LED to circuit board.

- 5.4.4. Once you have one transistor, resistor, and LED connected you can plug in the battery pack. You should see about a seven second period with no light, then the LED will glow for about a second, then repeat.
- 5.4.5. Now solder in the other seven transistors Q2-Q8, resistors (14) R2-R8, R14-R20, and LED's D2-D8. Test again. This time you should see the LED's light up, one at a time, in sequence, and keep repeating.

6.0 Mechanical Assembly

6.1. Flexinol® Guides

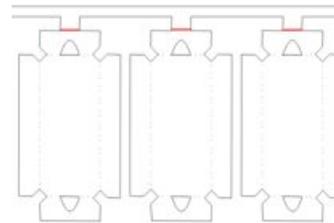


Fig. 6.1: Cut guides from carrier as shown.

The Flexinol® guides are sent to you attached to a carrier strip, as shown in Figure 6.1. We do this because individually they are VERY easy to lose. We recommend you wait until you are ready to glue them in place before cutting them off the carrier, then work over a large baking pan or a tray with raised sides. That way when you drop them (not if) you have a chance of finding them. We give you a couple extra guides, but you can lose a lot of them if you aren't careful.

- 6.1.1. First you will need to fold up the four sides of the ten longer Flexinol® guides, so it's like a tiny tray with handles on two sides as shown in Figure 6.2.

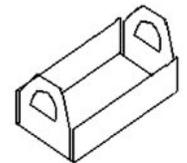


Fig. 6.2: Fold up large guides as shown.

5.3. Counter Circuit

Next you will connect the 4022 counter.

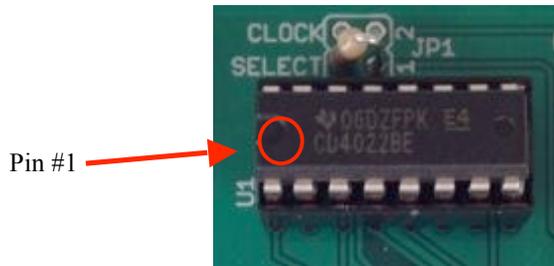


Fig. 5.4: 4022 Counter

- 5.3.1. Solder the 16 pin DIP socket the same way you just did the 8 pin and insert the 4022, again making sure pin #1 is aligned properly and notches are aligned as in Figure 5.4.
- 5.3.2. Also insert R13 into its position and solder.
- 5.3.3. Insert 0Ω resistor into SP1 pin 1 and Select.
- 5.3.4. Now if you have a multimeter and connect the battery pack you should be able to measure pin 1 staying low for about seven seconds, then going high for about a second. If it doesn't, check the soldering and ensure that pin #1 is in the right position.

5.4. Output

Now we will connect the output. First we need to connect the outputs to the 4022 IC. Note that the outputs are labeled 1 through 8. Let's connect #1.

- 5.4.1. First, insert the transistor into the position labeled Q1, looking at the markings on the PCB to make sure it is aligned properly. You will see that the case of the transistor has a flat on one side. Then solder in place.
- 5.4.2. Solder the resistor in place at R1 and R14 orientation of resistors doesn't matter.
- 5.4.3. Next solder the LED into position D1*.

*Determining orientation of LED's requires care. LED's are normally not labeled, but they only work in one direction. If you connect a multimeter set to measure high resistance, you will show a resistance value when connected in the right direction. In the other direction you measure open circuit. Also, if you hold the LED up to a light you will see some metal inside as in Figure 5.5. One of these sides is substantially larger than the other- the larger side is positive. Also LED legs have two different lengths. The longer side is positive. You can match the flat side of D1 shape and the “-” side of the LED as shown in Figure 5.6.

4.0 How It Works (Cont'd)

Electrical

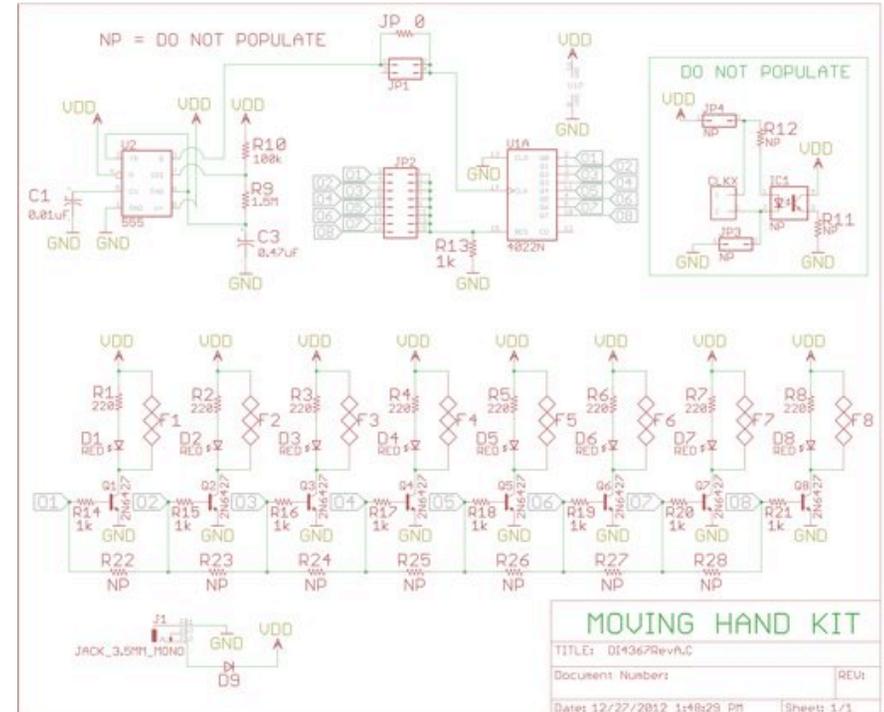


Fig. 4.6: Schematic of Circuit Board.

5.0 Electronics Assembly

5.1. Attaching Power

The first step is to get power to the PCB. The mini jack allows you to easily connect and disconnect the power supply.

- 5.1.1. Put the mini jack into the PCB as in Figure 5.1, with the end where you plug into pointing out, and solder it in place.

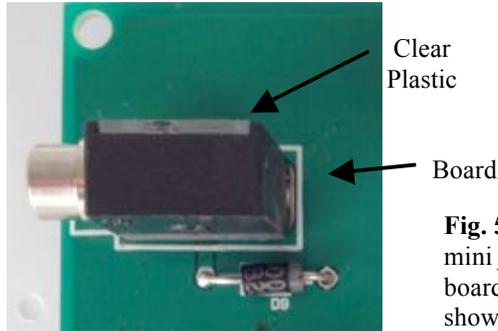


Fig. 5.1: Location of mini jack on PCB board. Place jack as shown.

- 5.1.2. Take the mini plug and remove the outer cover.
- 5.1.3. Slide the outer cover over the two wires so that the threaded portion is closest to the open end as in Figure 5.2.
- 5.1.4. Solder the red wire to the center connector on the plug, then solder the black wire to the outer connector as in 5.2.



Fig. 5.2: Wiring to plug. Mini jack soldered to battery pack.

- 5.1.5. Put the batteries into the battery pack.
- 5.1.6. If you have a multimeter, test now. With the black or negative lead connected to the longer or body section of the plug, the tip of the plug should measure about +6 or more volts.
- 5.1.7. Solder diode into D9 position. The gray tip should match the tip marked on board.
- 5.1.8. Attach power to jack and test the power before and after the diode. It should drop 0.6~0.7 volts.

5.2. 555 Timer Circuit

Next you will put the 555 timer into the circuit. Note that it can be put in two different directions, only one of which will work. There is a notch in the IC, which tells you where pin #1 is. If you hold the IC looking at the top with the writing towards you and the pins facing away, with the notch at the top, the #1 in is on your upper left. There is a matching mark on the circuit board, and on the DIP socket.

- 5.2.1. First put the socket into the PCB with the notches matching as seen in Figure 5.3. Solder all the terminals.
- 5.2.2. Insert the IC into the DIP socket.
- 5.2.3. Next insert and solder R9, R10, C1, and C3.

Warning: C3 is a tantalum capacitor, which is a type of electrolytic capacitor. If you look at it carefully you will see a little “+”. This side needs to be connected on the positive side, which is connected to 555 lead #2. The other side of the capacitor is connected to ground. You can tell this by looking at the bottom plate of the PCB where you will notice the terminal circled with a dotted line.

At this point you have a circuit that does something when you put four AA batteries into the battery pack and plug it in.

- 5.2.4. If you have a multimeter, connect the negative to the body connection of the jack or to pin 1 of the DIP (they are the same), and measure the voltage at pin 1. You should be able to see the voltage at pin 3 switch between low and high. If it doesn't, verify that the IC is inserted correctly, that the PCB is getting voltage, and that the resistors and capacitors are inserted correctly.

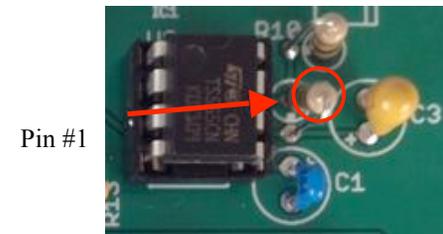


Fig. 5.3: Diagram of 555 showing pin #1 location.