ACTUATORS

OVERVIEW

Actuators

Motors

Controlling motors

Other types of actuation

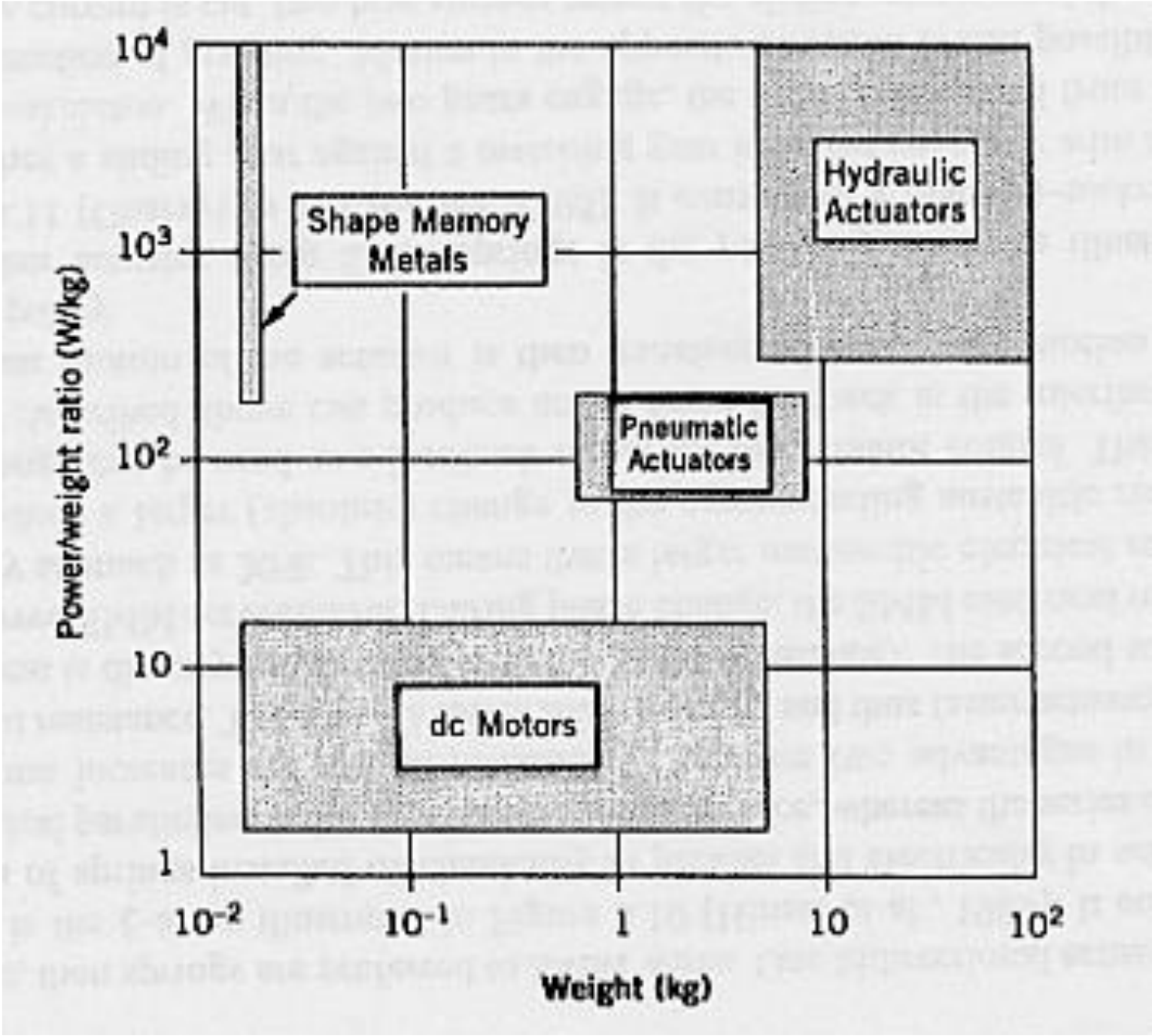
- Skin stretch
- Electrovibration
- Smart materials
- Piezo
- Pneumatic
- Force feedback

ACTUATORS

An actuator is a component that is responsible for moving a mechanism.

Their source of energy can come from

- Electric voltage
- Hydraulic fluid pressure
- Pneumatic pressure


Power/weight ratio (W/kg)
10^4
10^3
10^2
10
1
Shape Memory Metals
Hydraulic Actuators
Pneumatic Actuators
dc Motors
10^{-2}
10^{-1}
1
10
10^2
Weight (kg)

MOTORS

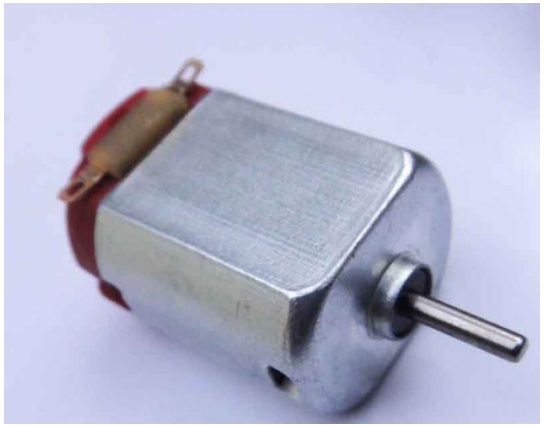
DC MOTORS

The DC brush motor is one of the simplest motors you can use

Brushed DC motors can be varied in speed by changing the operating voltage

Turns continuously when power is applied.

If you want it to spin in the opposite direction, you reverse the power.



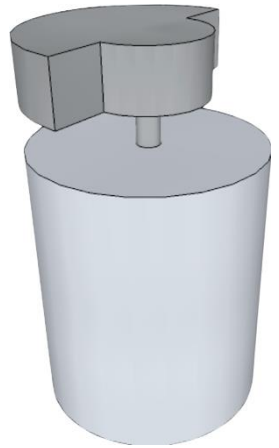
ECCENTRIC ROTATING MASS ACTUATORS

A motor spins an eccentric mass

Vibratory frequency and acceleration amplitude linked

- the acceleration amplitude of the vibration grows quadratically with the angular velocity

DC motor with an offset (non-symmetric) mass attached to the shaft.



The majority of mobile phones contain an

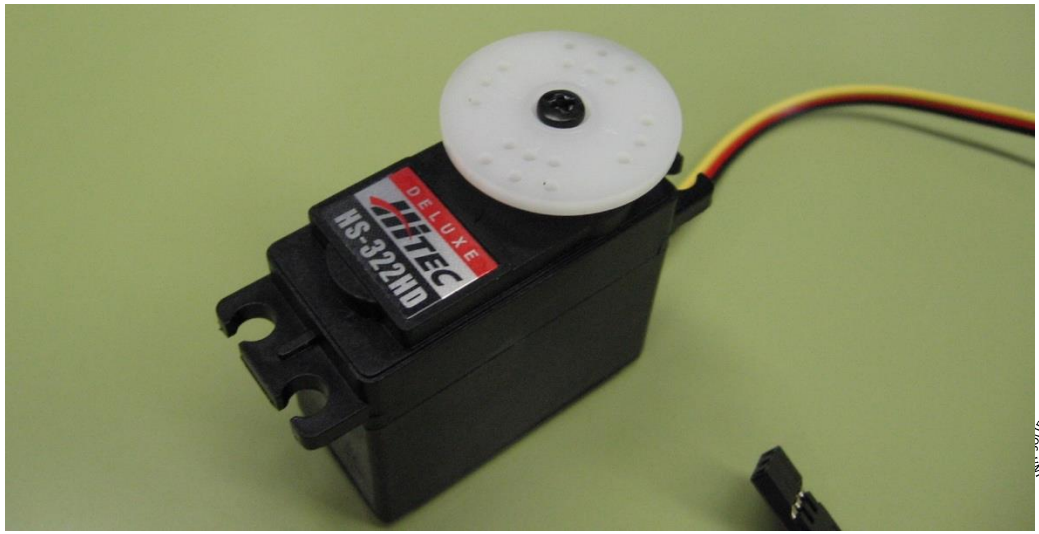
SERVOMOTORS

Servos are instructed where to turn

The servo has three wires –

- power and ground, plus a third wire, to carry instructions.

Servos often come with multiple attachments, such as wheels or levers, known as “horns”, than can be attached to the shaft, to fit the device they are operating.



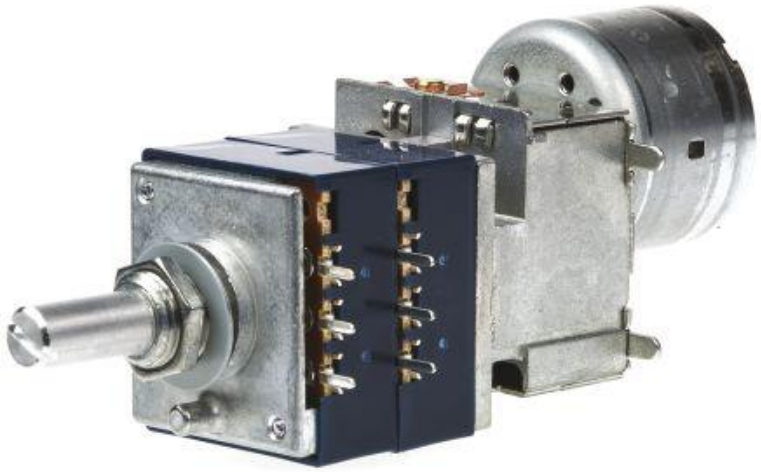
MOTORISED POTENTIOMETERS

Linear or rotational motion

Basically consists of a standard slide or rotary potentiometer, which is belt-driven by a small DC motor.

Not very powerful

From Sparkfun

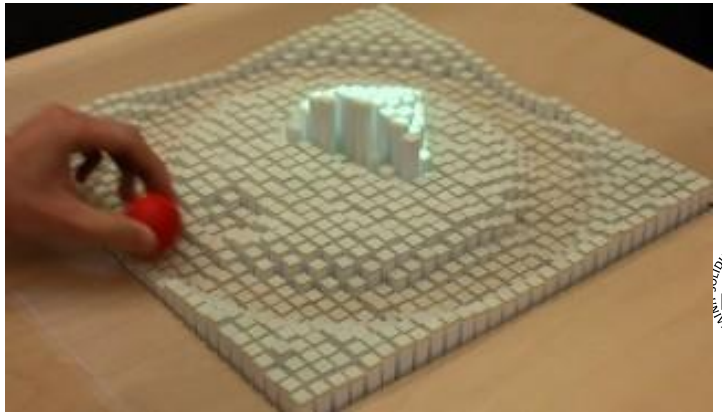


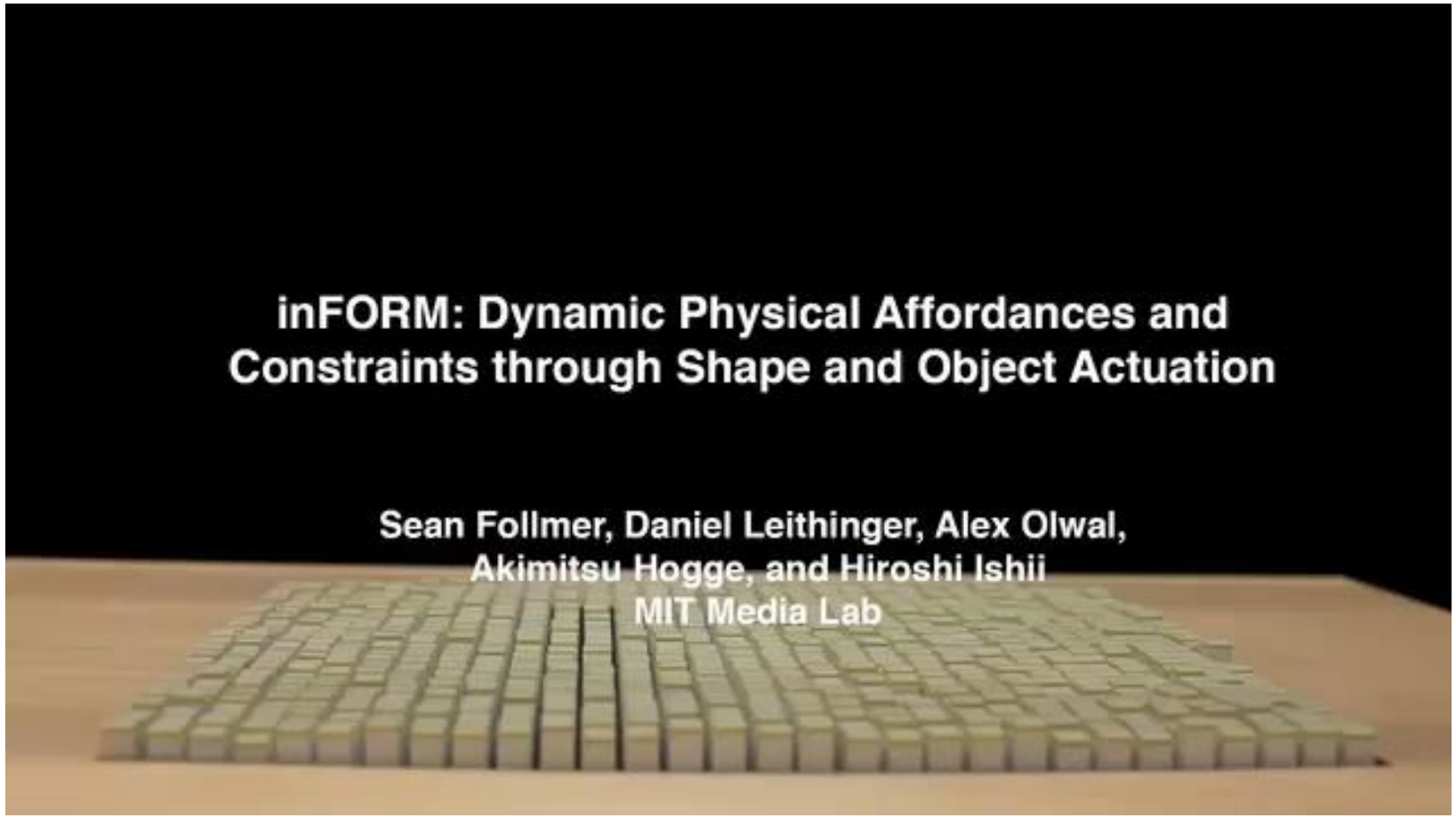
From RS Components

INFORM

2.5D actuation, malleable input, and variable stiffness haptic feedback.

Follmer, S., Leithinger, D., Olwal, A., Hogge, A., & Ishii, H. (2013, October). inFORM: dynamic physical affordances and constraints through shape and object actuation. In Proceedings of the 26th annual ACM symposium on User interface software and technology (pp. 417-426). ACM.




inFORM: Dynamic Physical Affordances and
Constraints through Shape and Object Actuation
Sean Follmer, Daniel Leithinger, Alex Olwal,
Akimitsu Hogge, and Hiroshi Ishii
MIT Media Lab

STEPPER MOTORS

Stepper motors are good for position control.

Steppers are a special segment of brushless motors.

You can use them to incrementally “step” to the next position.

SOLENOIDS

Solenoids create linear motion.

A solenoid is basically a coil of wire with an iron shaft in the center

When the coil is given current, it creates a magnetic field, and the shaft is pulled or pushed as a result.

When the current is turned off, the magnetic field disappears and the shaft moves back

They have only two positions, on or off.

LINEAR RESONANT ACTUATORS

Can create many different textures and intensities.

They use electromagnetic actuation to drive a mass linearly

Extremely strong

Can control frequency and amplitude separately (in AC).

The EAI C2 Tactor is an LRA

CONTROLLING MOTORS

H-BRIDGE

Designed to drive a motor clockwise and anticlockwise.

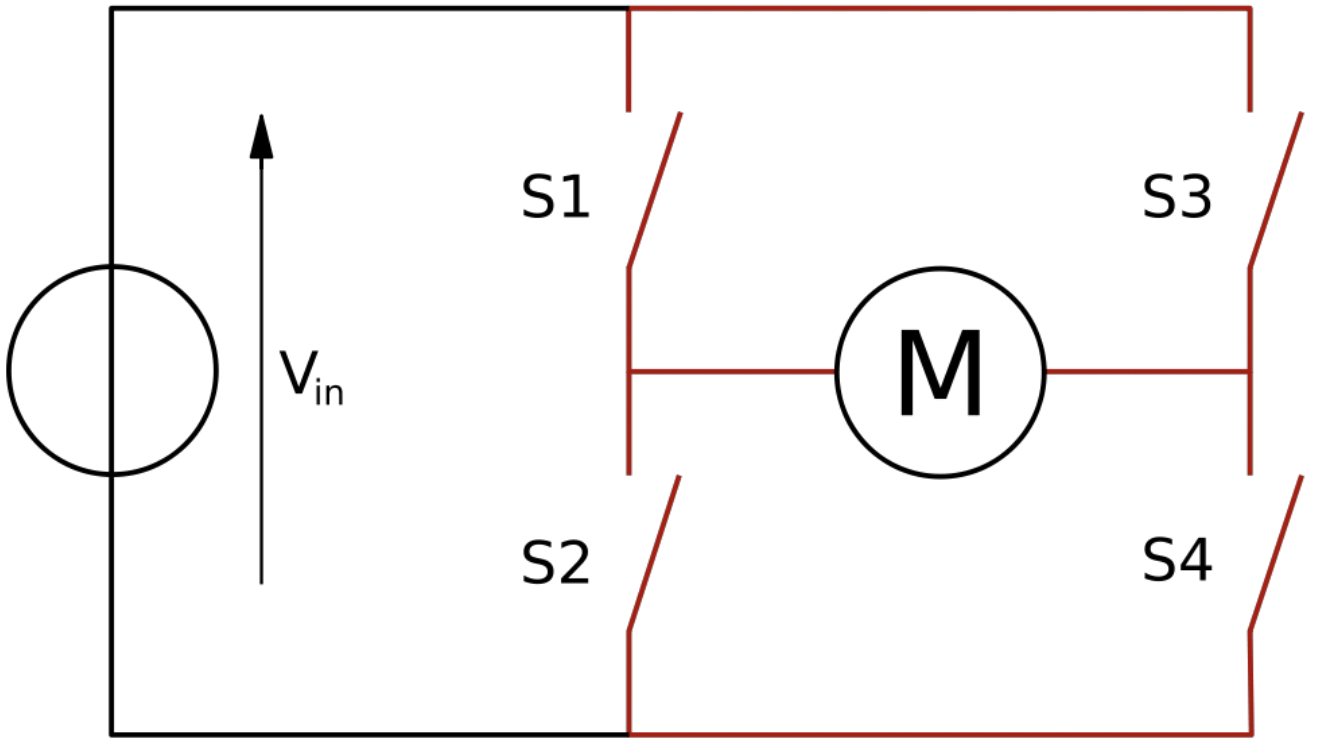
An H-Bridge can be made with SWITCHES, RELAYS, TRANSISTORS or MOSFETS.

Choice of H-Bridge design depends on

- number of transistors
- the type of layout
- the number of control lines
- the voltage of the bridge

DC MOTOR: DIRECTION CONTROL WITH AN H-BRIDGE

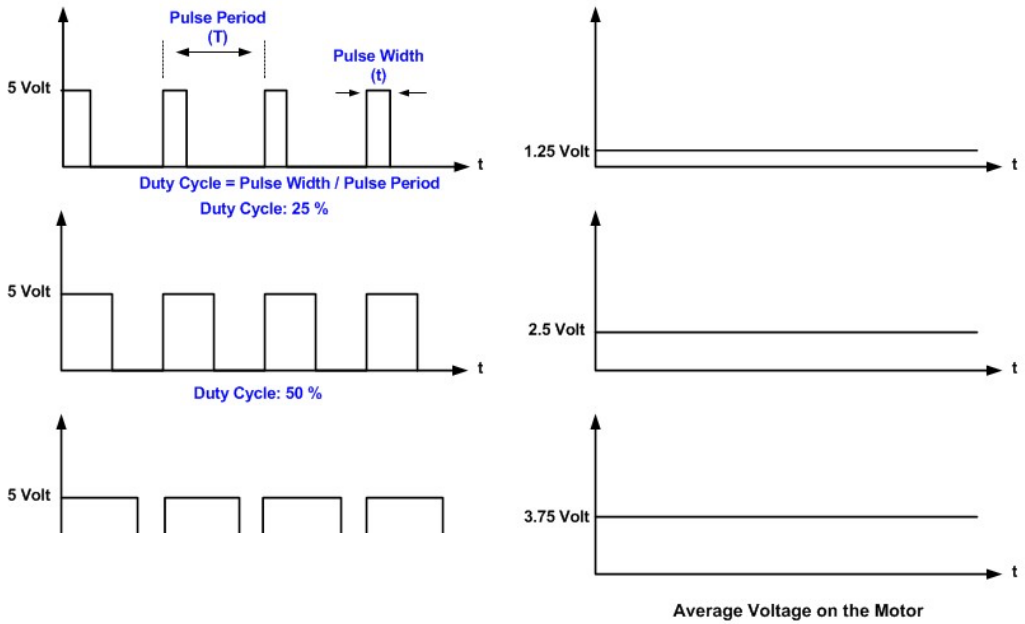
S1	S2	S3	S4	Result
1	0	0	1	Motor moves right
0	1	1	0	Motor moves left
0	0	0	0	Motor free runs
0	1	0	1	Motor brakes
1	0	1	0	Motor brakes



CONTROLLING SPEED WITH PULSE-WIDTH MODULATION (PWM)

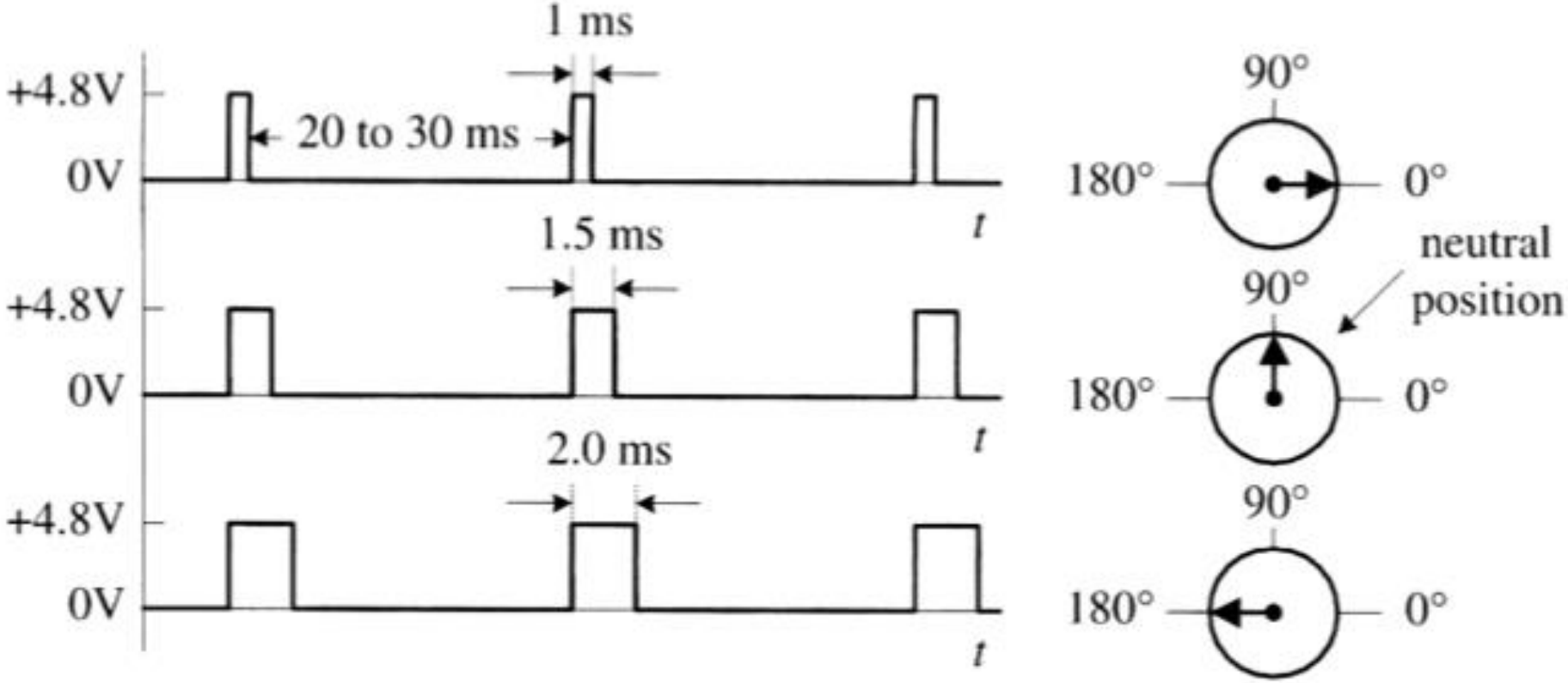
PWM speed control drives a series of “ON-OFF” pulses and varies the duty cycle

By changing or modulating the timing of these pulses the speed of the motor can be controlled ie, the longer the pulse is “ON”, the faster the motor will rotate



PWM Timing Diagram

A typical servo-control signal and shaft-position response



POWER CONSIDERATIONS

Microcontroller pins: 3.3V, 4mA max

Many motors, solenoids, etc. require 9-24V, and draw >1A.

Need a secondary power supply and appropriate switching circuitry (must combine ground of both supplies!)

WHERE TO BUY MOTORS?

https://www.precisionmicrodrives.com

http://www.robotshop.com/eu/en/motors-actuators.html

SMART MATERIALS

SHAPE-MEMORY ALLOYS

Shape-Memory Alloys (SMA) and polymers are materials in which a deformation can be induced and recovered through temperature changes.

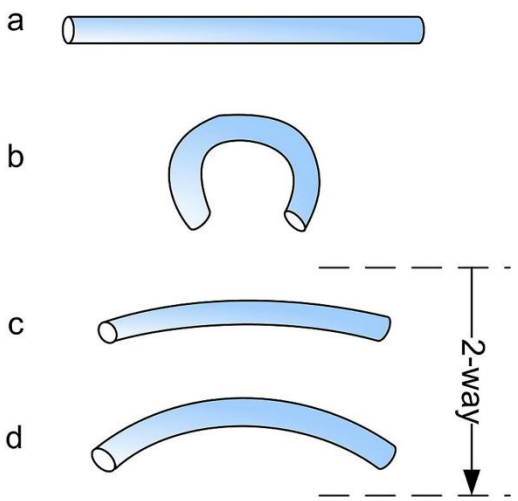
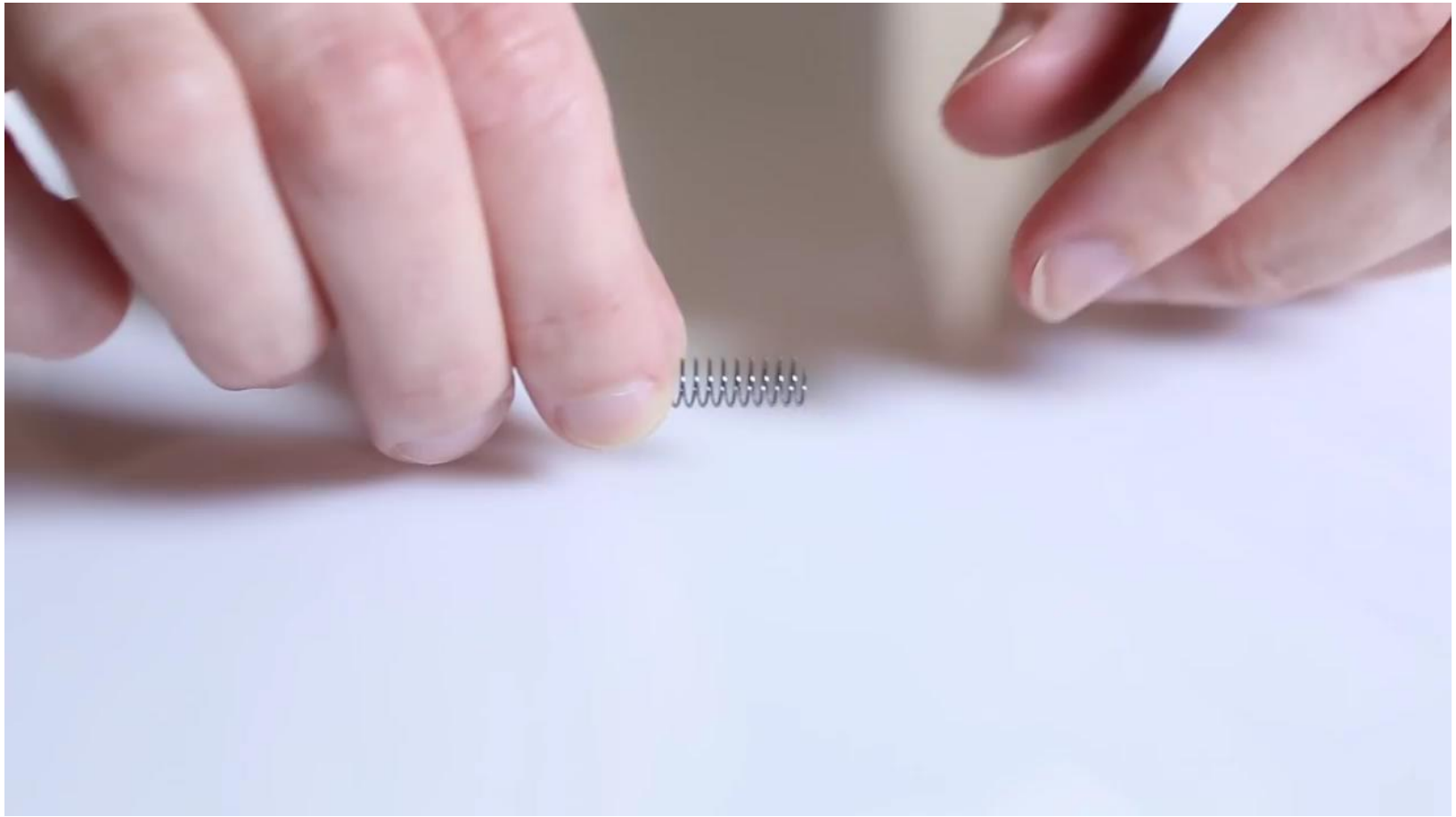
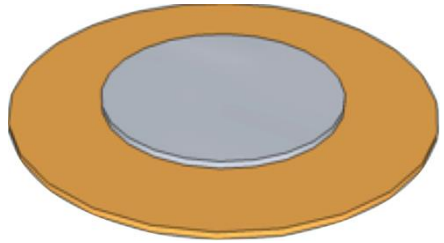


Image from wikipedia.org



PIEZO-ELECTRIC ACTUATORS



Piezo-electric actuator

Piezo-electric actuators can create short more localised tactile feedback, by moving touch screen display modules within the device.

The piezo-electric actuator can provide displacement very quickly, but with less kinetic energy compared to traditional vibration motor systems.

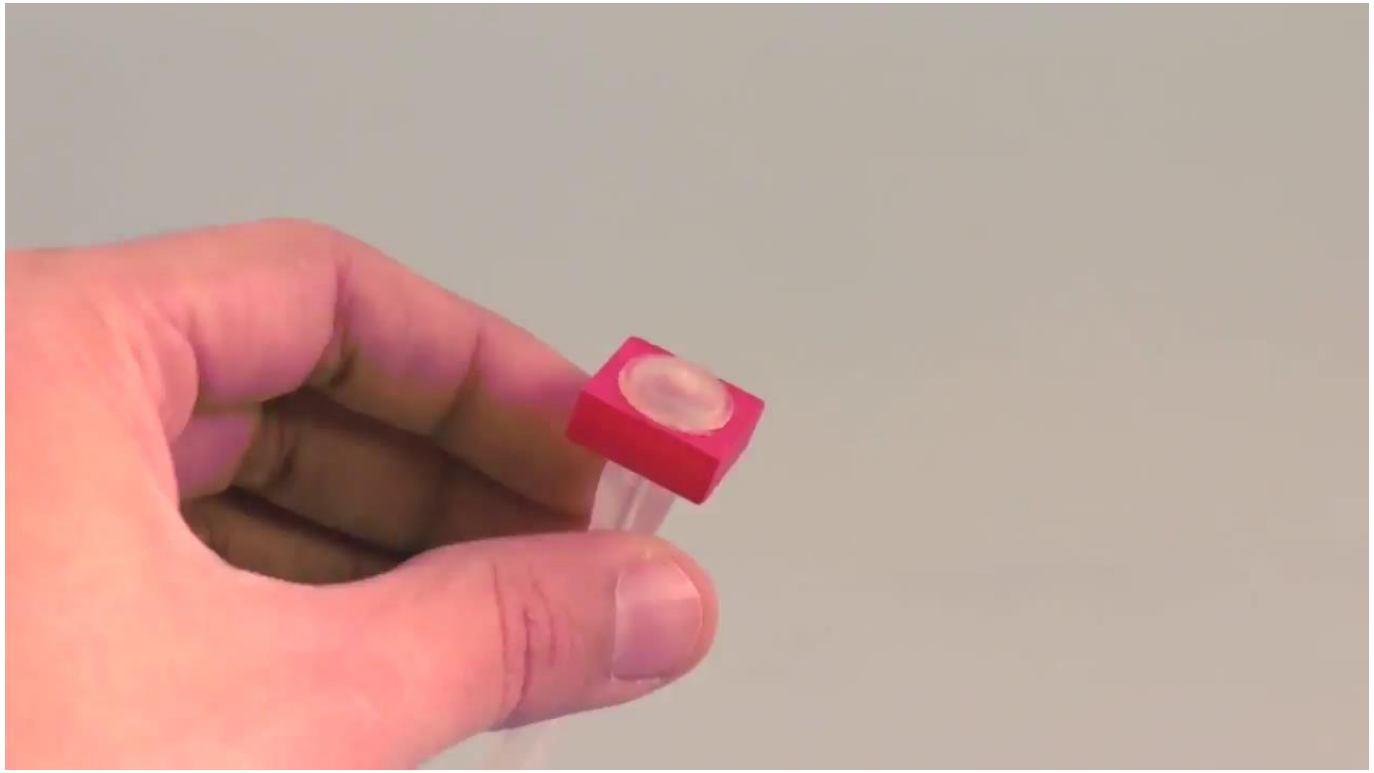
PNEUMATIC ACTUATION EXAMPLES

PNEUI

Yao, L., Niiyama, R., Ou, J., Follmer, S., Della Silva, C., & Ishii, H. (2013, October). PneUI: pneumatically actuated soft composite materials for shape changing interfaces. In Proceedings of the 26th annual ACM symposium on User interface software and technology (pp. 13-22). ACM.

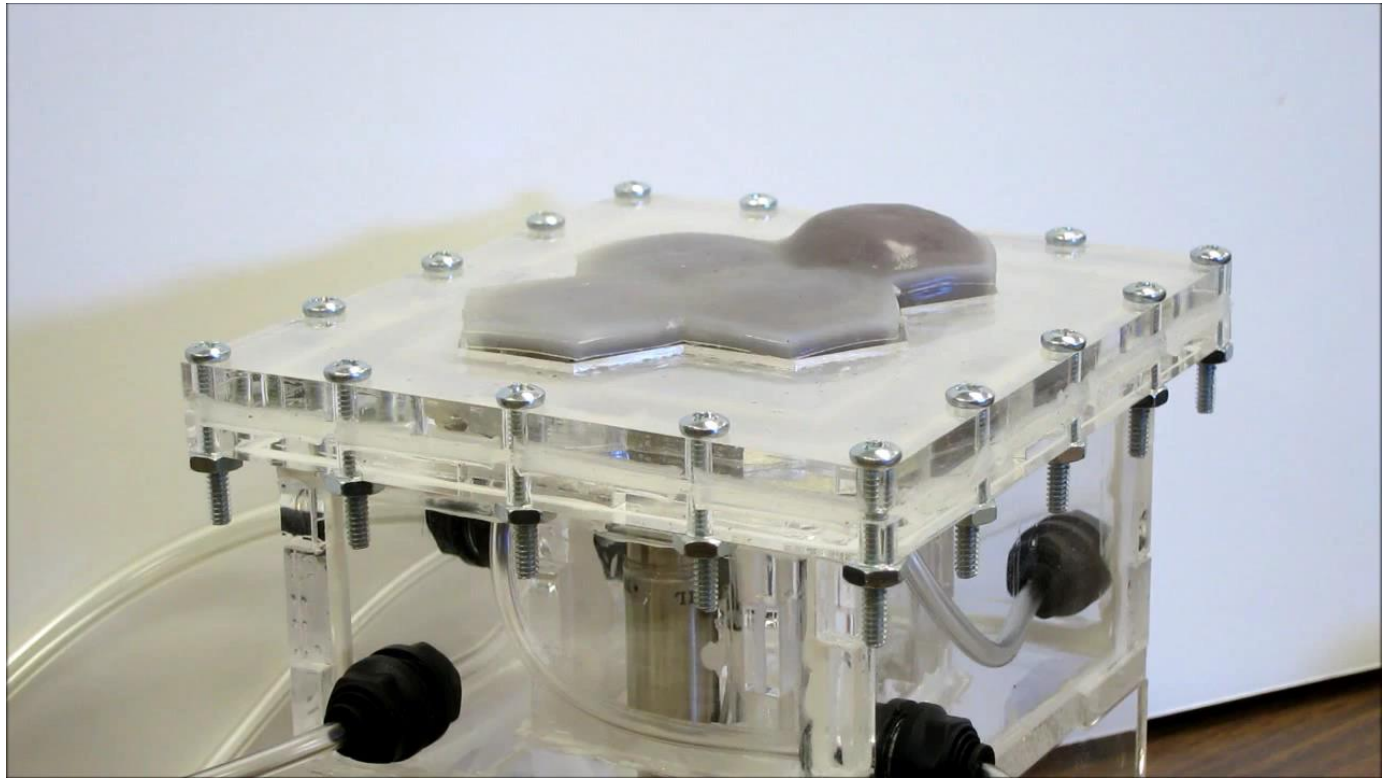
3D PRINTING PNEUMATIC DEVICE CONTROLS WITH VARIABLE ACTIVATION FORCE CAPABILITIES

Marynel Vázquez, Eric Brockmeyer, Ruta Desai, Chris Harrison, and Scott E. Hudson. 2015. 3D Printing Pneumatic Device Controls with Variable Activation Force Capabilities.



CONTROLLABLE SURFACE HAPTICS VIA PARTICLE JAMMING AND PNEUMATICS

Stanley, A. A., & Okamura, A. M. (2015). Controllable surface haptics via particle jamming and pneumatics.



MAGNETS

MAGNETO HAPTICS

ELECTROMAGNETS

SUMMARY

Actuators

Motors

Controlling motors

Other types of actuation

- Smart materials
- Piezo
- Pneumatic
- Force feedback

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