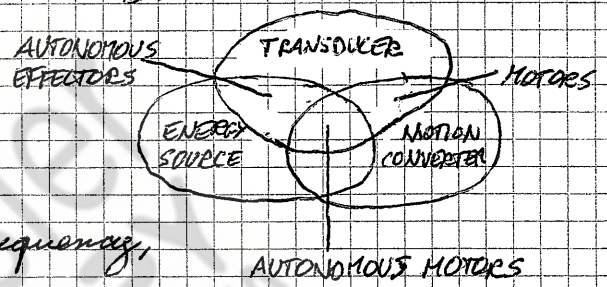
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ACTUATORS

When you deal with a new phenomenon, you pass three phases in order to obtain an actuator from it:
- mastering of the phenomenon;
- mastering material features;
- developing appropriate actuation concepts

New technologies are richer in behaviours, safer and mostly programmable

An actuator is a system able to provide mechanical action in requested time. It is composed by:
- transducers, which convert an energy form into a mechanical one;
- energy source;
- motion converter



Fundamentals characteristics of actuators are stress, strain, frequency, power density, transducer efficiency, bulk ratio, ecc.
We have to be able to compare different actuators between them. We can use Ashby diagrams, because it informs about technology areas materials can cover.

ELECTROMECHANICAL ACTUATORS

When an electric current passes through a coil, a magnetic force makes it to rotate. When the coil becomes orthogonal to the magnetic field, current must be inverted in order to continue the rotation. This is achieved through brushes, which are the main disadvantage of these actuators. In brushless motor, there are no brushes, they are not needed anymore, by changing roles of stator and rotor. In this case, you give power to the stator, and not the rotor anymore.
In stepper, rotation is achieved by changing the rotor to successive equilibrium positions.
In AC motors, alternate current is used. Here, interactions become smoother and faster. AC motors are synchronous or asynchronous, according with the ~~re~~ rotation


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velocity variation of rotating magnetic field and of the rotor.

EFFECTOR = Monolithic actuator

rotor = Composed by different parts

PIEZOELECTRIC MATERIALS (ACTIVE)

They have been discovered in 1880. When you apply a mechanical stress to these materials, its structure is rearranged, generating an electric ~~energy~~ field. The opposite effect is available, too, (inverse piezoelectric effect). This is due to the presence of dipoles. By that, piezoelectric materials* actuators can be realised with dielectric and ferroelectric. Moreover, it must be such as you can orientate the direction of dipoles. Applying a high voltage, you are able to orientate them. In the time, they tend to reassume their original position, but variation is not so relevant.

PE materials are single crystals like quartz, ceramics, polymers and their composites. Pros of PE's are:

- high torques provided;
- high speed;
- they lock when off: when voltage is applied, strain persists when voltage is shut down; for eliminating it you have to apply an inverse voltage;
- no magnetic fields;
- low inertia, because they depend on deformation and not movements of the materials
- strength ness in compression

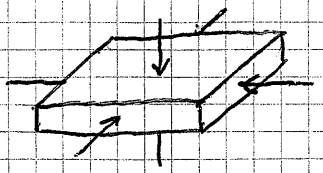
Their cons are:

- very small deformation (0,1 ÷ 1,8 %);
- low stability, as they degradate in their behaviour;
- weak in tension;
- highly subdued to fatigue.

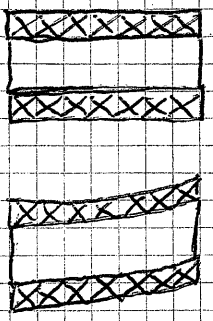
* Dielectrics present dipoles, when an external electric field is applied. This causes the piezoelectric properties. In a ferroelectric random dipoles are already present, and need an electric field to be properly oriented (poling process)

PIEZOELECTRIC ACTUATORS

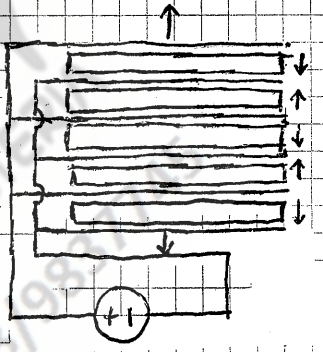
In PE materials, you can apply three different kinds of deformation. They're combined ~~in order~~ for getting particular effects.



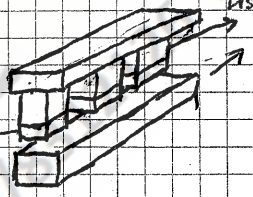
One of these is bending. A passive layer is interposed between two PEs. By applying the voltage, ~~they~~ PEs would tend to elongate. But, being attached to the passive layer, they bend.

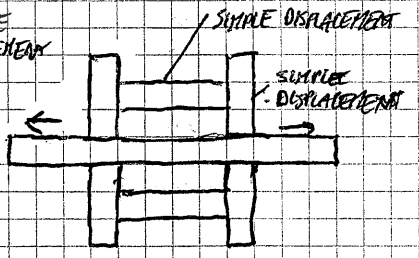


Another possibility is reached through stacking. Here, PE layers are put mechanically in series and electrically in parallel. By that, we get the same external force, but a strain equal to that one ~~got~~ obtained by one PE multiplied by the number of layers.

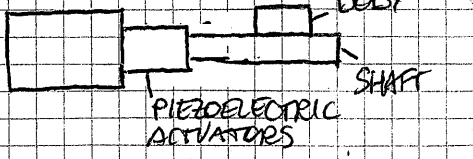


Using PE materials, we get piezo-motors. A first kind of them is quasi-static, obtained through combination of stacking and bending. They can be stepping or inchworm.





Another smart application is relies in their capabilities of resisting to movements. We could use them for moving objects through their slow extension and leaving them with fast extension.



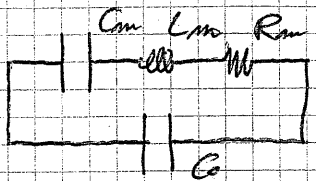
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ULTRASONIC MOTORS

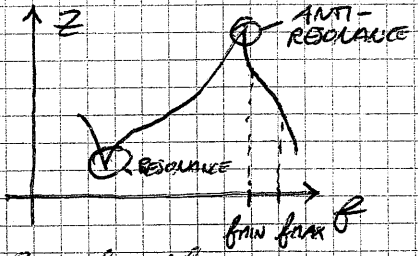
Ultrasonic motors exploit resonance of material, for producing movements. A resonant behaviour can be represented with the circuit below. Of this, we usually

consider the quality factor, defined as

$$Q = \frac{\sqrt{L_m / C_m}}{R_m}$$

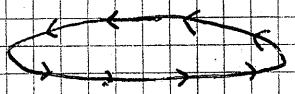


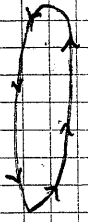
It gives to us an idea about how much this material is good to transduce electrical into mechanical energy



In the anti-resonance behaviour, there is a frequency interval in which the frequency response is quite linear. This proportionality is used to control the motor.
How can we exploit resonance for macroscopic motion?
Vibrations of material are transformed in small elliptical movements, by applying two voltages in orthogonal directions. The point locus of positions in time using two different sines for signals are called Lissajous curve. If the two sines differ only in phase, they form a Lissajous circle.
To the interacting surface of actuators to external, an elastomer is put. It is used for transmitting the movement to the target. In the first ellipse, we get a quite good movement, but a low force. With the other one is just the opposite.







Different movements can be achieved by changing type of waveforms, frequency, amplitude and phase.
Applications
Uses of ultrasonic motors are consumer electronics to compensate human tremor, microsurgery, swarm robotics and nanometers.

FLEXIBLE FLUIDIC ACTUATORS (ACTIVE)

They exploit fluid power. They are usually composed by of a chamber, a piston and flexible material. The