# An introduction to Robotics with LEGO® MINDSTORMS (V)

## Actuators for the NXT

*Text and pictures by Koldo*

In the previous issue of Hispabrick Magazine, we talked about ho a robot feels, i.e. how it gathers information from its surroundings by means of sensors. But in addition to a sensor system, in order to be able to interact with the surroundings, it also needs some system that allows it to carry out the task it will be assigned.

The NXT has different ways for doing things:

- A small screen that can show messages: text, numbers or even drawings and animations.
- A speaker that can reproduce sounds.
- A wireless communication system by BlueTooth that allows it to send and receive messages from a total of three other NXTs.
- A high speed port (S4) by mean of which it can communicate with another next through a cable and
- Three motor ports.

In addition to this it is possible to increase the number of outputs for motors by using a multiplexor. The one you can see in the image can be used to connect two motors to s sensor port (in addition to the sensor) although this requires an external power source.



This article is about actuators, i.e. elements that will produce circular or linear movement or effort.

### Circular movement

The most common actuator is the continuous current motor. The characteristics that define it are the speed and torque.it can produce. You can connect both the original NXT motors as well as PF motors to the NXT. You can also connect the older Technic motors, but ever since the introduction of the PF system these are much less useful with the NXT.

### -NXT Motors

What differentiates the NXT motors from other motors is the fact that they incorporate an encoder. What is an encoder? It is an optical device that allows you to measure the turning of a motor. In the case of the NXT, it is capable of measuring turns with a 1º precision. This device, together with the program that controls the motor, makes it possible to make the motor turn the fraction of a full turn you wish: a quarter of a turn, half a turn, 37º...

This system also solves a problem that occurs with other motors: the NXT continuously receives information about the turning of the motor, which makes it possible to synchronise two motors in such a way that when you mount them on either side of a vehicle, both will turn the same amount and the vehicle will drive in a straight line (this is difficult with othr motors that don't send information about their position to the NXT because even if they are similar, they probably won't turn at exactly the same speed).

### -PowerFunctions Motors

When LEGO® started changing the type of parts it used in Technic models -and as a consequence in MINDSTORMS - it had to design new motors as it wasn0t easy to adapt the old ones to the new models. The result was the PowerFunctions (PF) system, with two motors of different size (M and XL) and a system that allows you to remotely control them by means of infra-red communications.

Contrary to the NXT motors, these motors don't give any feedback about their position to the NXT so it isn't possible to control their turning in the same way. In many cases this won't be a problem, especially when a robot uses other sensors to gather information. These motors need two adaptor cables in order to be able to connect them directly to the NXT (LEGO references 8528 and 8886).



### -Controlling PF motors by infra-red communications

What's interesting about the PF motors is that they can be remote controlled by infra-red signals This means that if you use an "IR link for PF motors" (as can be seen in the image of all the elements of the system, with the aspect of a sensor) you can control up to 8 PF motors independently, using an NXT sensor port. In this case, the motors need an independent power supply.

### Rectilinear Movement

Although it is possible to convert a circular movement into a rectilinear movement using gears (something we do each time we use a car), there are constructions that for a number of reasons (space, characteristics of the movement, ... ) why this could turn out to be problematic. In these cases we use linear actuators, which allow you to generate a linear movement of limited length.

### -Pneumatic cylinders

Pneumatic cylinders, commonly used in industry and automation were the first linear actuators produced by LEGO®. The LEGO Pneumatics system consists of the following parts: air compression elements, an accumulator to store air, a valve for air distribution and the control of different elements and cylinders to carry out the work. Recently LEGO has produced a manometer to measure the air pressure.

In order to use these elements with the NXT you must keep in mind that there are no motorized valves and I don't recommend this system to anyone just starting out with LEGO MINDSTORMS.

### -PF Linear Actuators

PF linear actuators are a good alternative to pneumatic cylinders, especially because, contrary to pneumatic elements, they allow for intermediate positions in their travel. In order to control them from the NXT, they must be fitted with a motor, for example like in the following image.

In this case the only way to precisely control the position of the piston rod is to use an NXT motor or placing a rotation sensor between the motor and the cylinder.
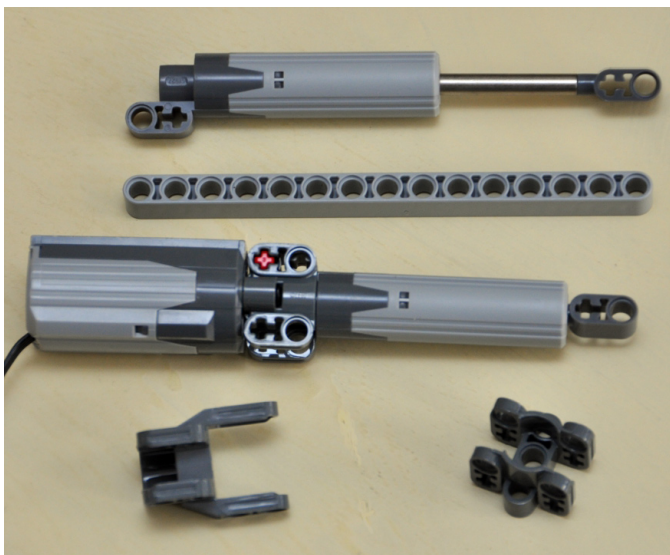


### -FIRGELLI Linear Actuators

The FIRGELLI linear actuator - you can see one in the following picture - has an internal motor that can be directly connected to the NXT. It is available in two sizes, 50mm of expansion (the one in the picture) or 100mm. Using the corresponding programming block you can control its movement both in millimetres and in studs.
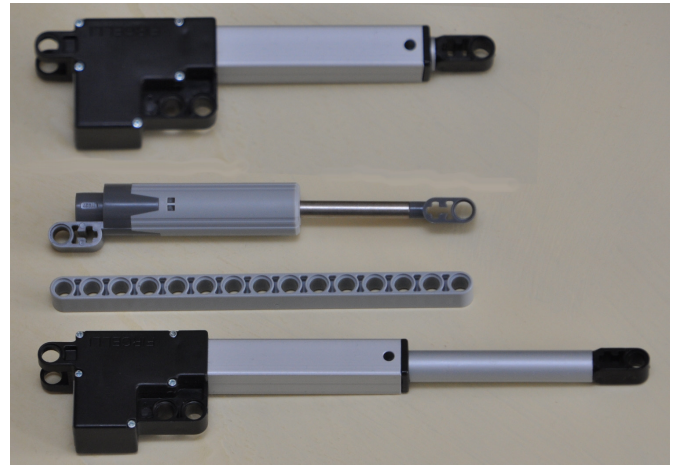


The only inconvenience of this element is its price: 50$ and 55$ for the 50 and 100mm versions respectively.
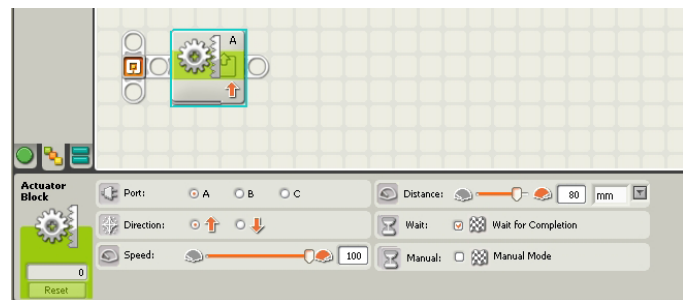


### Others

If you want to go even further, there are elements that allow you to connect other types of actuators to the NXT. Among these are the servomotor controller that you can see in the following image. By means of this controller you can connect up to 8 servomotors as used in radio controlled models to the NXT, which generate turns of 90º, 180º and continuous turns.
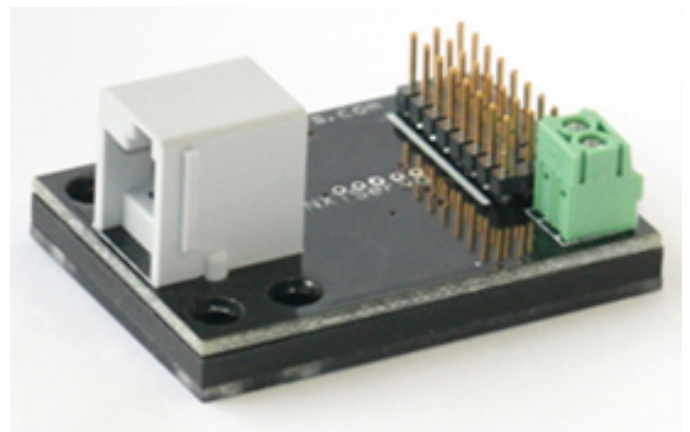


An excellent website or more technical information about LEGO motors is Philo's web http://www.philohome.com/ #


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