

## **Servomotor Usage for Controlling Fire Extinguisher Nozzle**

### **Introduction**

In the operation of a fully automated robot, the use of stable control systems is required to allow the robot to complete the given task effectively and reliably. These control systems will be controlling motor that will be counteracting the force produced by the off-the-shelf fire extinguisher and also acting as an aim corrector. High torque servomotors will be a great motor option, since it allows precise control of angular or linear position while able to support high load. This technical review paper summarized some commercially used high torque servomotors for robotic limbs, the technology of servomotor and its usage in robotic limbs, and the implementation of the servomotor in parallel with the fire extinguisher load.

### **Commercially Used High Torque Servomotor for Robotic Limbs**

Given the smallest size of the off-the-shelf fire extinguisher has an operating pressure of 100 psi [1] and nozzle diameter of 1.5 inch, than the force produced will be around 80 kg. With that in mind, one of the best high torque servos that can be use will be the HS-645MG from a South Korean company HiTec. With its three metal gears and dual ball bearing setup, it has a stall torque of 7.7 kg•cm when performing at its lowest operating voltages of 4.8 V and only weigh 55.2 g [2]. This servo is priced at US\$29.99 [3].

Other than HiTec servo, FeeTech, a Shenzhen based company, also offer a more powerful servo with the same three gears and dual ball bearing setup. Their FS5115M servo has a peak stall torque of 14 kg•cm, which almost double the one from HiTec, when operating at its lowest voltage of 4.8 V, but weighs more at 58.5 g [4]. This servo is marketed at US\$19.95 for single purchase and lower for bulk [5].

### **Technology of Servomotor and Its Usage in Robotic Limbs**

Inside the packages of servomotor, there consist of a small DC motor, potentiometer, and a control circuit. The control circuit can precisely regulate movement and direction based on the potentiometer's resistance change that is affected by the rotation of the motor, which is attached by gears to the control wheel. These operation sequences allow the servomotor to have precise

position control. The servo is controlled using PWM signals similar to DC motor, where the pulse width or duty cycles determine the angle or position of the shaft, such that in general min pulse width of 1 ms correspond to 0° and max pulse width of 2 ms correspond to 180° [6].

With the need of high torque servomotor for controlling high load object, modification to the original concept of servomotor was made. By utilizing the gear ratio concept [7], gears of different diameter are introduced into the servo that in return increases its output torque. This is why most high torque servos have 3 metal gears setup, where the metal material is needed to accommodate the extra torque [2,4].

Due to its ability to adjust position precisely, servos are perfect candidate to be use in application of robotic arm, particularly in the joint. One of the possible design concept can be seen in Novabot, where two servos are utilize to preform two axis movement that allow higher degree of movement freedom [8].

### **Implementation of the servomotor in parallel with the fire extinguisher load**

The implementation of servomotor requires the use of microcontroller, where the control system is installed and communicates with all servos on the device. With microcontroller already available, six servomotors are needed order to create a maneuverable robotic arm, which will be used to aim the nozzle to the target fire [9]. The total cost if Hitech servo is used will be US\$179.94 [3]. However this cost can be reduced if the Feetech servo is used instead, which reduced the cost to US\$101.7 [5]. Other alternative would be by using the Novabot design [8], which only require 2 servomotors to implement, reducing the cost to US\$59.98 (Hitech) or US\$33.90 (Feetech) [3,5].

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