Efficient DC Motor Control System

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Abstract

Three-dimensional (3D) imaging is a technique of combining two-dimensional data into a 3D format to develop the illusion of depth. By capturing the object multiple times at different angles, this method creates depth and dimension to an image. In dentistry, 3D imaging using x-rays is used to provide an enriched view of teeth and other oral structures (jaws, gums, etc.) for early diagnosis of dental problems. Although there are products sold on the market that will perform this job effectively, the cost for only the motor with a desired control system in that product is already expensive, and hence, not cost-effective for mass production. The company, Three-Dimensional Intra-Oral Imaging (3DIO), was needing help finding a motor control system that was cheaper than what was available on the market. The company could find a motor with a desired control system for about $500; however, any other option at a lower cost would benefit the company's cost savings.

Further requirements for the product are that the system must be designed to rotate an x-ray source 360 degrees (a full rotation) in three seconds while stopping every 100 milliseconds to take an x-ray image. In other words, the project is to design and construct a control system that controls the rotation of a DC motor around an axis in order to create a cone-shape of x-rays at a certain speed so that the system is capable of capturing 30 images in a time frame of three seconds.

Apparently, a low-cost unit whose functions are similar to that of the off-the-shelf products will significantly increase the company's profit and the cost of mass production is effectively brought down. While

a similar system costs about $500, if the desired system can be manufactured at around $200, then the cost is saved up to $300 per unit. With each completed unit saving $300, if the company is to produce 10,000 units, the cost is reduced by three million dollars! The saving will then be transferred to the clients, reducing the cost of their dental visits.

The system would need a motor with a rotating shaft and a microcontroller to control the speed of the motor. In addition, it would need an encoder that will be measuring how fast the motor shaft is rotating and sending that information to the microcontroller so that the microcontroller can adjust the motor speed. In other words, the complete product includes three major components: a DC motor, an encoder, and a microcontroller. The x-ray source is attached to the DC motor, which performs rotations under manipulation of the encoder and the microcontroller in a feedback loop: after the DC motor has started working, the encoder will determine the position of the motor so as to produce digital signals that will be notified to the microcontroller; the microcontroller will then change the DC motor's direction and speed to the desired result by a built-in PWM and an H-Bridge circuit.

The microcontroller, including the PWM (Pulse Width Modulation), needed to be programmed. Research on all the components of the system as well as how to get them to work together has been done. After that, the parts needed for the project were chosen and purchased. From here, they needed to be implemented and put together as a completed system. The encoder chosen for this project was a continuous potentiometer. This was chosen because potentiometers are more cost-efficient compared to most other encoders. The potentiometer tells the microcontroller where the motor is at in its rotation by giving the microcontroller its current resistance value. The microcontroller deciphers that resistance as an angle and then the microcontroller knows how far along the motor is in its rotation. If the motor needs to move faster or slower, the microcontroller will adjust the amount of power going to the motor using PWM.