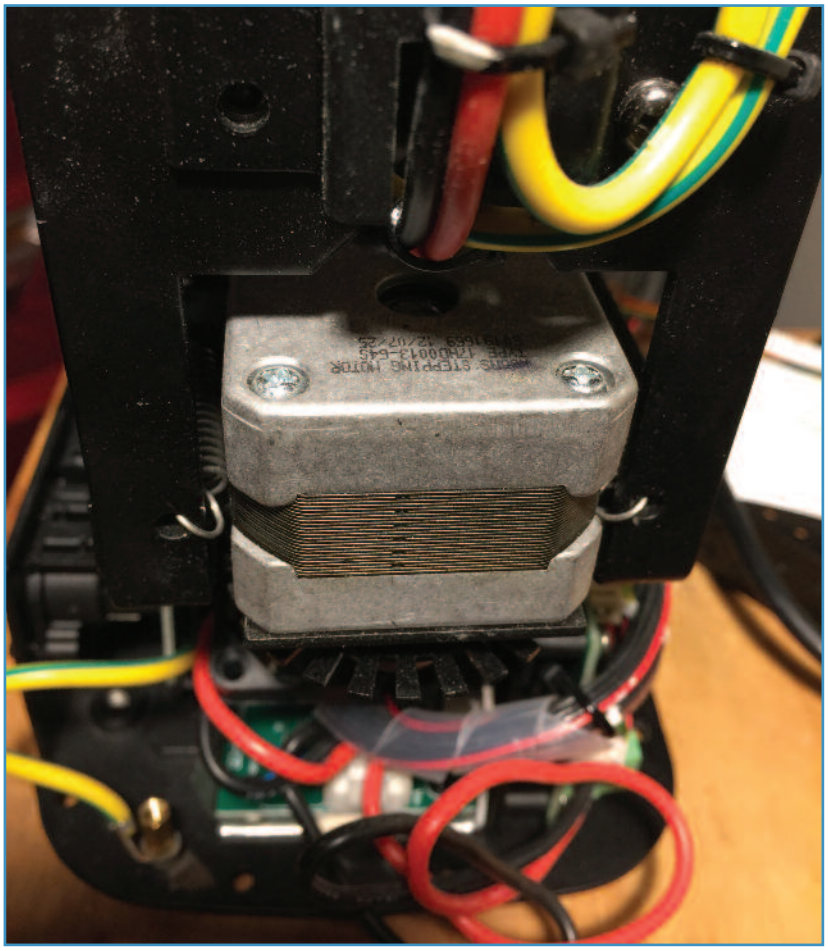


Stepping in the Right Direction

By: Richard Cadena

A stepper motor solution for an unusual prop design

I recently got a call from a friend who works with special effects in the movies, and he had an interesting project. Every year, throngs of people descend on Austin for the South by Southwest Music and Film Festival, and he was working on a prop for a major film opening. I can't say which film it was, because Hollywood is very protective of its intellectual property, and getting permission to name it would require moving mountains while simultaneously jumping through several very large hoops. Instead, I'll just say that it involves a big-name Hollywood producer and it has to do with a very large robot made of a particular type of metal. My buddy was contracted to build a replica of the beast and to make the eyes light up.



Stepper motors are sized according to mounting dimensions, shaft size, maximum holding torque, rated current, impedance, angle of rotation per step, and more.

After he accepted the project, he was asked if he could make the head swivel back and forth using DMX control. That's when he asked if I would join the project and help with the lighting and DMX control.

From the beginning, I knew that, given the very short time frame, it would be a challenge to pull off. But I'm a sucker for a good challenge, and I thought I had a solution, so I accepted.

Lighting the eyes to match the look in the movie proved to be fairly easy. We needed a single-source LED fixture with a diameter of about 6". I thought a PAR-type LED with a COB light source would work well, and it only took me an hour or so to find a fit, which was a couple of American DJ Dotz fixtures. We had them overnighted and they worked perfectly.

The real challenge was how to quickly cobble together a solution to remotely reposition the large Styrofoam and plaster head using DMX, one that would fit inside of the 13"-diameter opening that was carved out of it. We needed a motor with enough torque to overcome the starting inertia and keep it moving, one that could move smoothly, and one with enough precision to move the head from one angular position to another and stop smoothly. There are two ways to do this: with a servomotor or a stepper motor.

I thought using a stepper motor would be quicker and easier because a servomotor requires a feedback loop with position sensing, while a stepper motor only requires having a home position. And since time was of the essence, my mind immediately went to stepper motors.

A motor driver provides the control current to precisely control stepper motors. Some provide the ability to adjust the step size and speed.

Stepper motors are specified according to their mounting dimensions, shaft size, maximum holding torque, rated current, impedance, angle of rotation per step, and more. The sizes are specified by the frame size in inches, and the most common motor sizes found in automated lighting are NEMA 17, NEMA 23, and NEMA 34, which correspond to approximately 1.7", 2.3", and 3.4" square. (NEMA is the National Electrical Manufacturers Association.) The holding torque is related to the length of the motor; the longer the body, the greater the holding torque, but also the heavier and more expensive it is.

The key is to find a stepper-motor-and-motor-driver combination that provides enough torque to overcome the starting inertia of the load and accelerate it to a given speed as well as to slow it down and stop it. How to find the right size is probably the most common question that people have when working on custom automation projects like moving set pieces or soft goods.

There are lots of resources that explain how to calculate the required torque, but it seems like you need a degree in mechanical engineering to figure them out. I spent hours looking through documentation and trying to decipher equations and graphs, and I finally found something that makes sense to me. There's a series of videos produced by Automation Direct, explaining how to go about selecting the proper stepper motor for a particular application. (*Stepper Motors: How to Choose and Use, Part 2*—https://youtu.be/xqrbr_6L71Y) There's also an app you can download and run on a PC that makes it easier, though still not easy, to figure out the minimum torque requirements for your application.

Besides a motor, you also need to have a motor driver and DMX interface. But that's really the easy part. You will find lots of options by

googling "DMX stepper motor drivers."

I scarcely had enough time to research how to measure or calculate the required torque, much less to order the parts and have them delivered, so we just used trial and error. I happened to have a small moving-yoke LED fixture sitting in my office waiting for an application like this, and I thought it would work well. The only question was whether or not the little yoke had enough torque to move the relatively large robot head. When we tried it, we heard the sickening sound of the motor losing steps, meaning it was unable to overcome the starting torque. So, it was back to the drawing board.

I made a few phone calls to friends in the industry looking for a bigger, stronger yoke mechanism, and I ended up connecting with Scott Ingham, who had some hardware that we thought would work. Scott and I have a long history together. I first met him when he worked for a company in San Antonio called Cyberkinetics. They manufactured speaker cabinets, among other products. Scott eventually went to work for High End Systems designing electronic circuits for lighting products. He and I worked there for a number of years before we left to work for Hubbell Entertainment. He later started his own company, Ingham Designs, LLC where he designs electronics for OEM products and customer projects.

Scott brought over a stripped-down yoke mechanism, from a Hubbell moving-yoke fixture that never made it to market, and a small black box labeled "Stepper Motor Controller + Driver." The controller had an LCD menu display and several terminals to connect a stepper motor, some sensors, and DMX. It allowed us to quickly and easily connect to the existing stepper motor mounted inside of the yoke mechanism and control it with DMX. It also allowed us to adjust the size of the steps and motor speed, and when you lower the speed, it has the added bonus of increasing the torque. (You can accomplish the same thing with gears, but it adds to the complexity and space needed for the mechanism.)

Before we could install it in the robot, we ran out of time before it had to be installed. So the idea of moving the head via DMX was scrapped. Still, the finished product looked great, thanks to the artistry of the craftspeople who built it.

In researching the topic I learned that lots of people are building custom projects using automation and DMX. The maker movement is making it easier and more affordable to get the technology and find information. There are many helpful videos and websites, and though it can be challenging to build a project, it's always fun.