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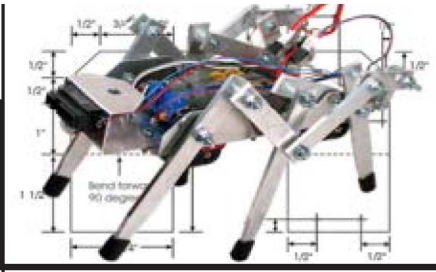


■ BY VERN GRANER

PING PONG PRINTER

IN THE DECEMBER ISSUE, I told you the story of The Ponginator — a 20-foot tall ping pong ball shooting, video screen sporting, light blinking, sound-blasting robot that the Robot Group built for Maker Faire in Austin, TX (Figure 1). The Ponginator was quite a hit, firing eight ping pong balls hundreds of feet out over the crowd every 30 minutes or so. Each ball was custom printed with the logo from The Robot Group and Maker Faire (Figure 2). Though a big success, one thing that sorta snuck up on us was the accumulated cost. Even when ordered in the 500 piece range, the commercially printed ping pong balls cost approximately 60 cents each. At the Maker Faire event, we were loading each of the four pneumatic guns with two balls per barrel on most shots (sometimes more); this resulted in each firing sequence costing almost $5! At this rate (about $10/hour), Ponginator was a bit pricey to operate. Since we had planned to use the Ponginator in other shows in the future, I wanted to find a way to bring the price of operation down. That meant finding cheaper "ammo."

The simplest solution would be to fire plain white ping pong balls. A bit of web searching found a number of suppliers that would ship a gross (144) of these for around $15. This would bring the cost from 60 cents down to just under 10 cents per ball. Although much more economical, the lack of any text or graphic really reduces the "neato factor" that the logo-bearing balls had. I really hoped folks would want to keep these as souvenirs of the event. With nothing special about a boring white ping pong ball, this would be highly unlikely. So the question was, could we somehow print something on the ball ourselves?

■ FIGURE 1. The Ponginator at Maker Faire in Austin.

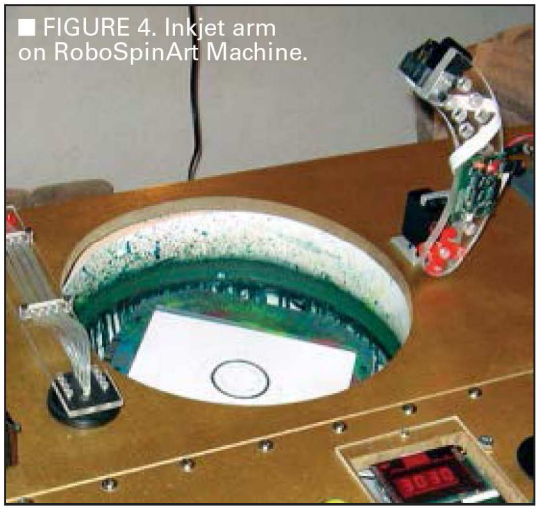
"PONGINATOR NEEDS AMMO BADLY!"

As those of you who read the article on the RoboSpinArt machine know (see *Nuts & Volts*, January '08), I use a serial inkjet printer kit from Parallax (Figure 3) mounted on a retractable servo controlled arm (Figure 4) to inscribe event info on each of the spin art cards just before painting (Figure 5). As I had experience using this kit, I performed a simple test to see if ping pong balls could be used as print media for an inkjet.

First, I hooked up the serial inkjet board and a continuous rotation servo

■ FIGURE 2. Commercially printed ping pong ball.

■ FIGURE 3. Parallax serial inkjet printing kit.



■ FIGURE 4. Inkjet arm on RoboSpinArt Machine.

to an EFX-TEK Prop-2 board (a very convenient BASIC Stamp II based controller). I wrote some code that would dump a single line of text to the serial print interface and then start the servo motor spinning. I placed a blank white ping pong ball on the servo and then held the inkjet cartridge at the "equator" of the ball.

Even with the inkjet cartridge hand-held, the printing came out looking pretty good. And, after drying for just a few seconds, it was both clearly visible and fairly indelible. I could rub the text, and it didn't smear or come off on my fingers.

Now that I had a proof of concept, it was time for some brainstorming on a mechanism with my favorite machinist and fellow roboteer, Rick Abbot.

SODA AND SKETCHES

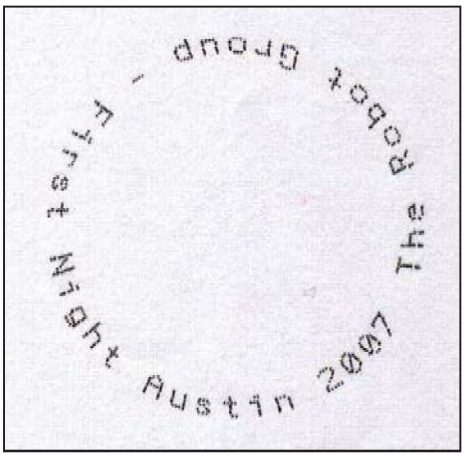
I lured Rick to a meeting at my house and stuffed him with soda pop and tortilla chips while I sketched out a design for a ping pong ball printer on the white board. He nodded sagely, made some notes and said he might be able to come up with "something" in a bit. He left with a few ping pong balls, a couple of servos, and the serial inkjet kit.

About a week went by, and I got a call from Rick asking if I might be available so he could bring something over. He showed up on my doorstep with the PingPongPrinter Prototype.

Wow! The device was a beautifully rendered Rube Golbergian masterpiece crafted from clear Lucite and aluminum. It was festooned with servos, linkages, push rods, and even an ammo "hopper" made from a five gallon water bottle with a gear motor driven agitator (Figure 6). The agitator had dual vertical rods held together with a dome shaped brace so it could stir up the ping pong ball ammo and make sure there was always a ball ready to drop (Figure 7).

Below the hopper was a loading tube managed by a servo motor controlled "indexer"(Figure 8). The servo was attached to a rotating disk to extend and retract two rods in the path of the ping pong balls. It had two simple, mutually exclusive positions: load and release.

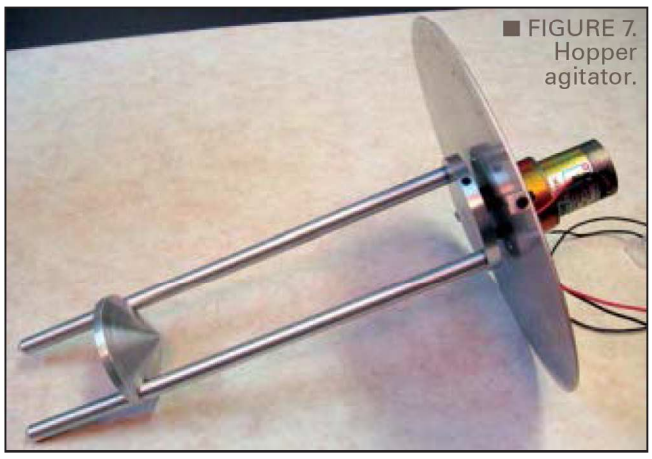
In the load position, the upper rod is retracted, allowing a single ball to fall down into the loading tube that is stopped from falling through by the lower rod. In release position, the upper rod is extended to block the load tube from the rest of the balls in the hopper while the lower rod retracts releasing one ball to fall down to the next stage.



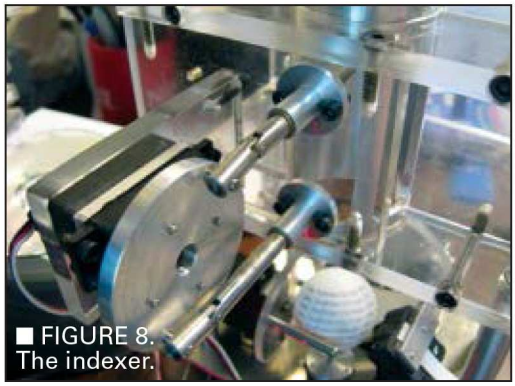
■ FIGURE 5. Inkjet printed text on spinart card.

Once a ball falls down the tube, it comes to rest on a small aluminum pedestal that was topped with a rubber o-ring for both traction and

■ FIGURE 6. PingPongPrinter prototype (shown here with agitator removed and placed in the foreground for clarity).



■ FIGURE 7. Hopper agitator.



■ FIGURE 8. The indexer.

■ FIGURE 9. Pedestal, print head, and eject servos.

shock absorption (to keep the ball from bouncing off; see Figure 9). The aluminum pedestal was perched on a continuous motion servo that could rotate the ball under the print head to allow lines of text to be printed. There was also a print head servo that would position the print head around an arc-shaped path. This way, lines of text could be written anywhere between the two "poles" of the ball.

Lastly, a servo motor controlled an eject mechanism that would gently push the printed ball from the pedestal when it was complete. As usual, Rick's amazing mechanical skills had placed a very nice mechanism in my hands (Figure 10). Now, I needed only to write some software to bring it to life.

READY, SET, CODE!

I attached the servos to the Prop-2 board, sat myself down, and stared at the device for a while. Though what it needed to do was relatively straightforward, as I started to make notes on each step in the printing process, it became clear that it was going to be an intricate task to get the printer to perform. I identified each specific function by following the progress of a ball from beginning to end:

1) Move all servos to initial/ready positions.

2) Agitate the ammo in the hopper.

3) Move the indexer from release to load position.

4) Wait for a ball to fall into the loading tube.

5) Move the indexer from load to release position.

6) Wait for the ball to fall and settle on the pedestal.

7) Repeat next steps one time per text message inscribed:

a) Send text string to the serial inkjet interface card.

b) Start the pedestal rotation servo.

c) Wait for one revolution of the pedestal.

d) Stop the pedestal rotation.

e) Move the print head to the next line.

8) Retract the print head to read position.

9) Move the eject servo to eject position.

10) Move the eject servo to ready position.

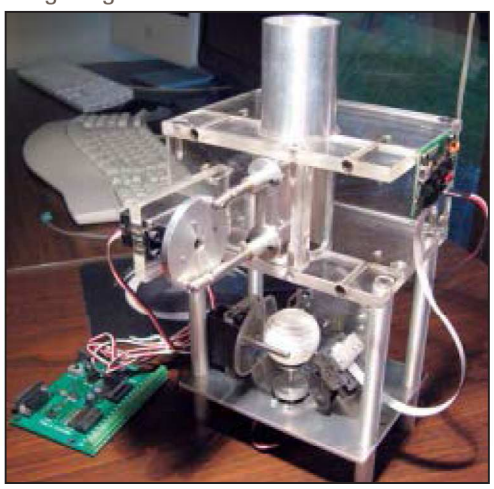
I next took the above functions and started to create subroutines that I could call in sequence. However, at one point it appeared that I would need to do two things at once (rotate the pedestal and send text to the print control board). Since the Prop-2 board is based around the Parallax BASIC Stamp, it's a bit tricky to make things appear to operate in parallel.

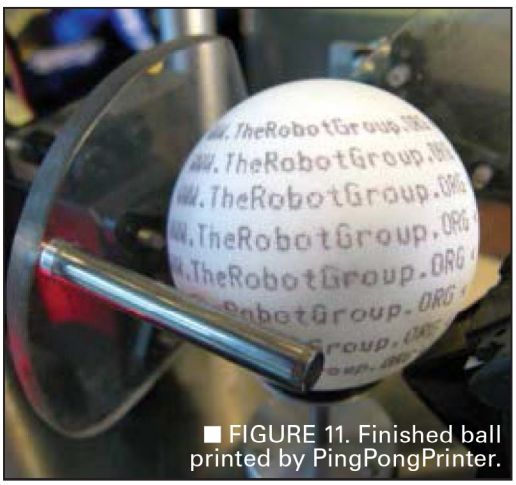
For example, in order for a continuous motion servo to turn, you must feed it a constant "diet" of pulses from the microcontroller. To make sure the pedestal would spin, I created a loop that would send a set of pulses every 20 ms to the servo. But, since the BASIC Stamp was busy sending pulses, it could not also send text strings to the inkjet.

I entertained the idea of some fancy-footwork programming (e.g., making the code jump out of the servo loop on every <x> iterations, fetch a character from the sentence to be printed, send that character to the inkjet, then jump back into the servo loop). However, I always prefer simple solutions during the dev cycle. This is especially important at the beginning of a project where you can waste a lot of time designing tricky code routines that you may later have to abandon if the project moves in another direction.

So, in an attempt at a quick fix, I decided to dump the entire sentence of text to the inkjet interface and then immediately start the loop that rotates the pedestal servo. The

■ FIGURE 10. Close-up of PingPongPrinter mechanism.





■ FIGURE 11. Finished ball printed by PingPongPrinter.

initial test of this method worked pretty well with one small issue. The first two to three letters of text in the sentence were printed on top of each other, making a vertical black line on the ball. The problem was that the inkjet unit would start to print text before the pedestal rotation could begin. There was a simple solution to this problem. I prefaced each text string with three "spaces" so the print head would print nothing before the pedestal could come up to speed. The resulting printed output looked surprisingly good (Figure 11).

Though I'm reasonably sure I could solve the parallel function issues by using a serial servo controller to run the pedestal servo (thereby freeing up the BASIC Stamp to send text), I prefer fewer parts and lower cost if I can manage it. After all, this whole project was motivated by the high cost of the pre-printed ping pong balls. Bottom line is that through trial and error, I've managed to get a working ping pong ball printer using just the servos and a single Prop-2 board. If any more features are added, I may have to switch to a serial servo controller. But, for now, it's nice to know I can print ping pong balls with a single microcontroller solution.

WRAP IT UP, I'LL TAKE IT!

Though the basics of the Ping PongPrinter have been accomplished (Figure 12), I plan to continue to improve it for use at other events. One of the first planned improvements is to place the device in some sort of case to make it more stable and to protect the mechanism from inquisitive fingers. I also envision adding more "bells and whistles" to the device to make its operation even more interesting to watch. The addition of LED lights to the various stages of the device would help observers to follow the progress of the ball as it makes its way from a blank to a fully printed final piece.

Once the entire printer is mounted inside a case, one possible delivery method we've been considering is using the Bernoulli Principle to "float" the finished ball up out of the machine on a cushion of air, leaving the ball suspended on a column of air above a delivery tube when the printing is complete. This would also help to make sure the ink was dry by the time the ball was delivered.

I've also considering adding a coin slot type mechanism to allow the machine to be used for fund raising at events. Some improvements on the inscriptions have also been discussed, such as in addition to the event information, a different fortune printed on each ball. I've also done some experimenting with moving the print head continuously while it is printing, creating a serpentine or candy-stripe text inscription as an additional effect (this effect might be the tipping point that forces me to add that serial servo controller, or maybe even move to a Propeller Chip!).

Anyway you look at it, this should be a fun project to advance. I've included a link in the resources area to a video of the printer in operation so point your browser there if you want to see the PingPongPrinter in action. Once the

RESOURCES

■ The Robot Group
www.TheRobotGroup.org

■ First Night Austin
www.FirstNightAustin.org

■ EFX-TEK
www.efx-tek.com

■ Parallax Serial Inkjet Kit
http://tinyurl.com/yt8g6h

■ PingPongPrinter Demo Video
www.youtube.com/watch?v=8Ep5OC3E02I

Rick Abbot is a master machinist and serves on the Board of Directors for The Robot Group, Inc.

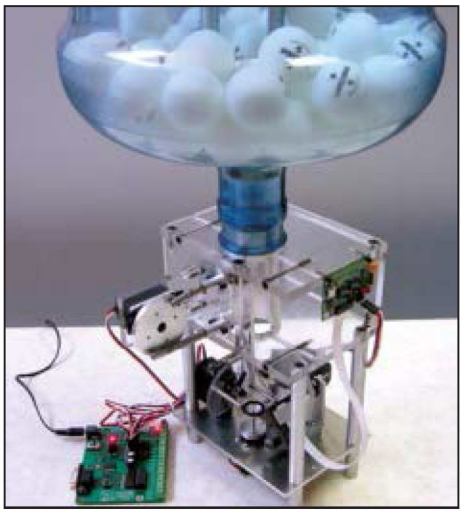
Vern Graner is President of The Robot Group, Inc., in Austin, TX and may be reached via email at vern@txis.com.

I'd like to thank the Austin Word Woman herself, Kate Howard, for her help in crafting this (and other) articles. Thanks Kate!

project has moved further along, I'll try and post some updated videos/pictures to **TheRobotGroup.org** website.

SHOW US YOUR BENCH!

To wrap up my column this month, I'd like to ask a favor of you folks, the readers. Recently, the topic of what I've dubbed the "Habitat For Hobbies" came up among some of The Robot Group members. We started discussing the ideal workbench for crafting and repairing electronics and robotics. I've always been curious about how people get things done in their own workspaces, so, I'd like to ask *Nuts & Volts* readers to take a picture of their workbench and send it to me. Include a description of the tools you think are essential, what you do like and don't like about your current layout, and what you would consider a perfect workspace for projects. Please feel free to offer any advice that would benefit someone just starting out, or that someone ready to remodel their workspace would benefit from knowing.



■ FIGURE 12. PingPongPrinter loaded and ready to print.

I plan to combine the advice and photos for a future article. I'll be taking a picture of my workbench (a.k.a., Disaster Central), so don't be embarrassed to send in a picture of your workbench — warts and all! Please email your submissions to vern@txis.com. Thanks! **NV**