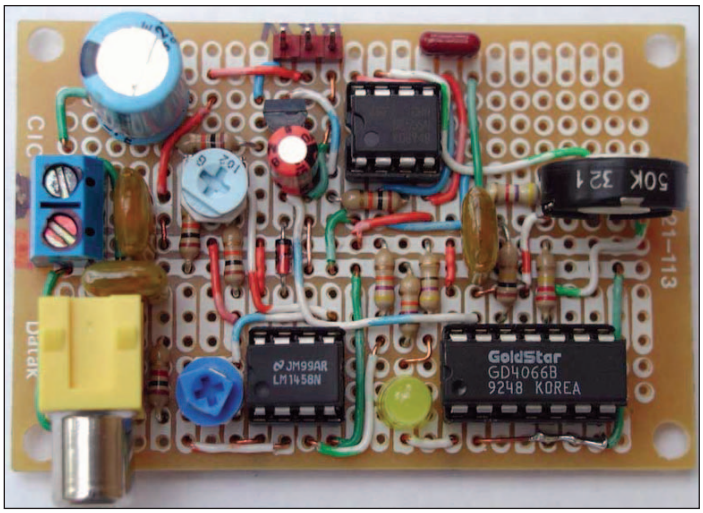
THE TALKING SKULL KIT

BY VERN GRANER

BOO! Fall is in the air and Halloween is just around the corner. It's time to start getting ready for those trick or treaters that will be coming to your door in just a few short weeks! Halloween is a fun time for make-believe and for kids (and adults!) to play "dress up." It's a time to make fun of the things that scare us and to have fun being scared. It's also a time where folks who have a bit of tech-savvy can impress the heck out of their neighbors.

An evening at the workbench spent crafting a new creation can result in laughter and screams from the neighborhood kiddos. "How did you DO that!?" is a phrase we all love to hear when someone gets a close-up look at something we've built. Soldering back together a broken battery connector or wiring up a boat trailer for the neighbor can only gain you so much credibility. If you want the "Joneses" to have to keep up with you this Halloween, an LED-eye blinking, servo-operated, animated talking skull may be just the ticket!

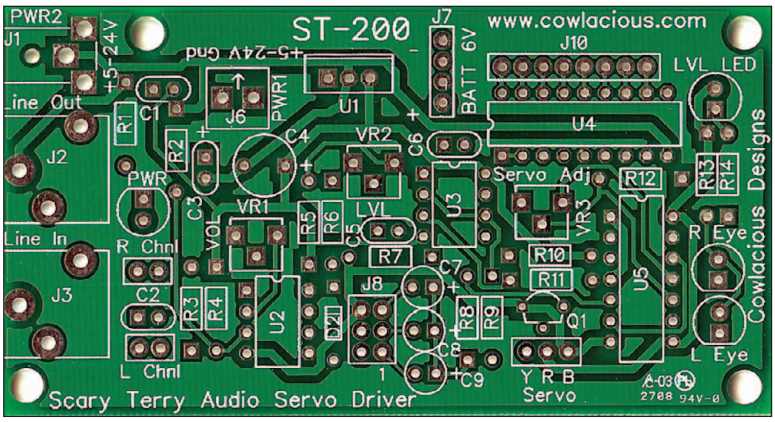


■ FIGURE 1. Prototype of Scary Terry audio servo board. (Photo courtesy of Terry Simmons.)

You May Ask Yourself, "How Did We Get Here?"

A carved pumpkin or a spooky scarecrow on the front porch is pretty typical fare for Halloween. But taking it to the next level requires a bit of skill and imagination. Enter Terry Simmons (a.k.a., "Scary Terry") of California State Polytechnic University, Pomona, CA. An avid "haunter" and electronics buff, Terry wanted to animate a life-sized plastic "Bucky" skull he had purchased. When he went looking for a way to accomplish this, he discovered that many of the motion systems for talking or animated props were pretty complicated. Some required a microcontroller or computer and expected you to invest hours of painstaking programming to coordinate all the servo motions to the sound track. Wanting something simpler, he decided to build a sound-activated circuit to drive a typical hobby servo motor. On his website, he describes the project:

"My goal in creating this was for a relatively simple, inexpensive, and reliable circuit that doesn't require programming a microcontroller for each individual movement. I've used several of these circuits over the last several Halloweens to provide mouth movements on Bucky



■ FIGURE 2. Cowlacious ST-200b version of the audio servo board.

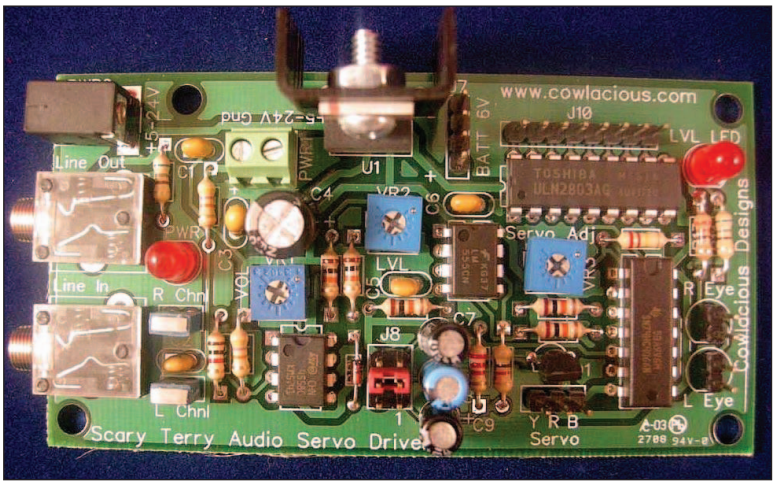
skulls and other animatronic heads. They have been a very reliable addition to my haunt."

The result was "Scary Terry's Audio Servo Driver." This small board detects any incoming audio signal and moves a servo motor to animate the jaw or mouth of a prop. This way, no programming is needed and you can change the sound track for the prop at any time.

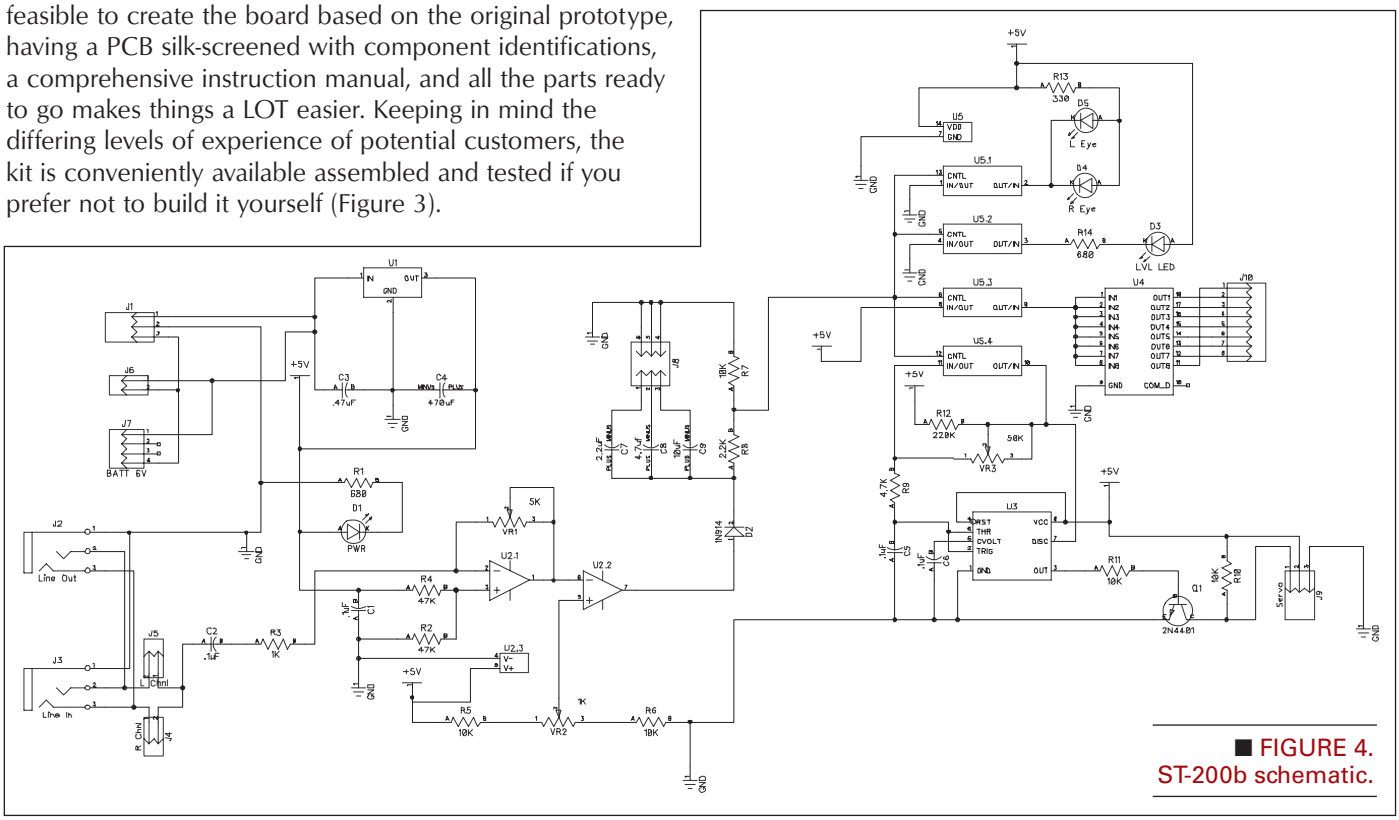
Terry made the schematics, parts list, and proto board circuit layouts available on his page (Figure 1) and even published detailed information on the circuit theory of operation. However, many folks found the creation of the circuit a bit too complicated or time consuming. Though the circuit was perfect for many haunter's needs, it really needed to be simplified and documented (i.e., "kitted") in order to make it more accessible to less electronically advanced folks.

Cowlacious to the Rescue!

As an electronics technician by trade, Carl Cowley (of Cowlacious Designs) was in the right place at the right time to create a kit around Terry's circuit. With Terry's permission and assistance, Carl took the original schematic design and laid out a number of different printed circuit board (PCB) revisions. He finally settled on the "ST-200b" version that was streamlined and made more versatile (Figure 2). Though it is still quite feasible to create the board based on the original prototype, having a PCB silk-screened with component identifications, a comprehensive instruction manual, and all the parts ready to go makes things a LOT easier. Keeping in mind the differing levels of experience of potential customers, the kit is conveniently available assembled and tested if you prefer not to build it yourself (Figure 3).



■ FIGURE 3. Cowlacious ST-200b fully assembled.



■ FIGURE 4. ST-200b schematic.

How it Works, Theoretically Speaking

To best use the audio servo board, it is important to explore the underlying theory of operation. Basically, the board works by detecting the presence or absence of sound. When sound is detected, the board instructs the servo motor to move from its "home" position towards a "target" position. When sound is absent, the servo is instructed to move back to the home position. When the servo motor is coupled to a jaw or mouth, the motions are surprisingly accurate.

If you have a look at the schematic (Figure 4), we can go over the operation in detail so we can really understand the parts and how they work. The audio signal enters through the 1/8" stereo jack J3. Jack J2 is wired in parallel so that the signal can exit the board to an external speaker system. J4 and J5 control which channel is passed to the next stage (i.e., left, right, or both).

The audio signal from J4/J5 passes through C2 and R3 which provide some isolation and the resulting signal is fed to the U2.1 op-amp which is configured as an audio amplifier. VR1 is used to adjust the input gain of the op-amp section to match the incoming audio signal level.

The output of the first op-amp is then fed to the second op-amp which is configured as a comparator. VR2 is used to set the threshold that triggers the comparator output. Jumper J8 is used to select which damping capacitor (C7, C8, or C9) is used to shape the decay of the trigger signal that feeds the U5 quad switch. Larger capacitance results in slower, smoother movement; smaller capacitance results in faster motion. When the audio signal is above the threshold of the comparator, the output of the comparator is passed to all four inputs of the U5 quad switch. U5 is then used to drive four separate outputs.

The first output (U5.1) drives a pair of remotely-mounted LED eyes that light up when sound is present. The second output (U5.2) drives an LED that is used as a guide to help you visually calibrate the board to the incoming audio level (i.e., it lights when the board is detecting audio). The third output (U5.3) is used to drive the ULN2803a driver and the fourth output (U5.4) is used to control the 555 timer.

The 555 timer is configured as an astable multivibrator and when the trigger level changes, U5.4 changes the timing resistor which shifts the PWM width from ~0.3 ms to ~3.7 ms (VR3 adjusts the 3.7 ms down to 2.0 ms or so allowing you to position the servo's home position). The PWM output is inverted and driven to the servo jack by R11 and transistor Q1.

The ULN2803a is used as a high-current driver allowing you to control devices such as incandescent lamps, small motors, relays, or solenoids. Though the ULN2803a has built-in back-EMF diodes, if you plan to drive some larger solenoids it might be a good idea to place an additional back-EMF protection diode in the circuit. The ULN2803a is a neat addition to the original prototype board and comes in handy if you decide you would prefer to have the audio servo board drive a solenoid valve connected to a pneumatic cylinder. This way, you could use the board to control the movement of very large puppet jaws or mouths weighing tens or even hundreds of pounds!

To assist in getting the best performance out of the circuit, the board has a series of adjustments that allow you to adapt the device to the sound track you choose. For example, you can choose which channel (left, right, or both) is used to drive the servo motor. This is important since the servo will respond to any sound it detects. Typically, you would want to use a separate channel for dialog and sound effects. Or, you can daisy-chain the devices together and have each talking skull respond to a different dialog track. This allows you to have a pair of skulls carry on a conversation! You can also use the J4/J5 jumpers to select which board should respond. The J8 jumper block is used to fine tune how responsive you want the jaw to be.

The Head Bone's Connected to the Servo Bone

Okay, so enough theory. Let's get to the application! As a member of the TXfx group in Austin, TX, I thought it would be fun to have a "Make and Take" with talking skulls. I sent out an email message announcing the idea to all my scary friends on the TXfx mailing list.

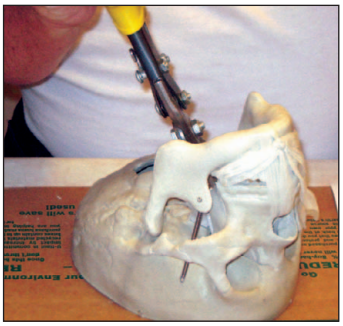
For those of you not familiar with the concept, a "Make and Take" is part work-day and part party-day. Folks with common interests and overlapping skill sets gather at a predetermined time and place to take on the same challenge. We meet up (usually on a weekend) and by cooperating and teaching each other, we each make a working device

■ FIGURE 5. TXfx members working at the skull assembly area.

■ FIGURE 6. TXfx members and folks from The Robot Group at the soldering area.

■ FIGURE 7. Eric Lundquist and Vern Graner (cleverly disguised as a giant pumpkin) at the system test area.

■ FIGURE 8. The Cowlacious ST-200b kit and color manual.



■ FIGURE 9. Tin snips used to remove a small part that blocks the mounting bracket.

■ FIGURE 10. Rotary tool used to smooth out the servo bracket mounting spot.

to take home. Of course, having some experts on hand (i.e., my buddies from The Robot Group) certainly doesn't hurt since they can help troubleshoot any issues that arise. A Make and Take is a lot of fun and is very effective in both learning new things and getting things done.

After my announcement on the mailing list, I counted up the RSVPs and it looked like we had about 10 folks from all around central Texas that wanted to make talking skulls, with some folks signing up to build a pair! To meet the demand (and to make sure I had one for myself), I ordered 12 complete Cowlacious Talking Skull kits with red LED eyes. (Note: See the Resources section to order a kit for yourself in time for Halloween!)

The weekend of the Make and Take arrived and we set up the center island in my kitchen as the "skull prep" area (Figure 5). The kitchen table was set up with three soldering stations for circuit board assembly (Figure 6). We also had some speakers and a small MP3 player for testing the finished units (Figure 7).

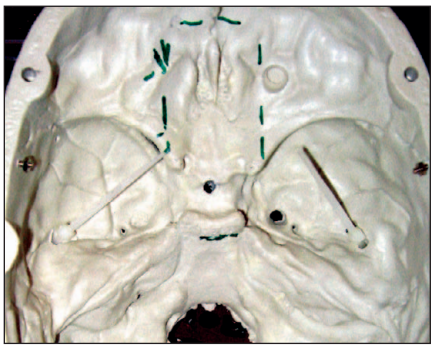
I opened the kits and was happy to see that each one was bundled with a full-color multi-page instruction guide (Figure 8). If you'd like to have a look, the instruction books are available directly from Cowlacious (see Resources) as PDF documents. The booklet had detailed instructions and photographs on how to modify the fourth class Bucky skull to hold the servo motor and allow a piece of piano wire to reach the jaw. There were also detailed step-by-step instructions on how to assemble the audio servo board in a separate color booklet. As you can see in the photos, we were all using these guides constantly as we went along and they were VERY helpful!

Though the skull modification guide is very detailed, the actual modification is fairly simple and can be recapped in short order: A small piece of plastic is "snipped" away from the bottom of the skull to make room for the servo bracket mounting screw (Figure 9). A rotary tool is used to smooth an area inside the skull for the servo bracket (Figure 10). The springs that hold the jaw to the skull are removed, then holes are drilled in the skull to allow clear plastic wire ties to act as hinges for the jaw (Figure 11). The servo bracket is attached to the skull with a nut and bolt (Figure 12) and then a hole is drilled to allow the piece of stiff wire (i.e., piano wire) to be threaded from the servo down to the jaw (Figure 13). Finish by attaching the servo horn to the servo (Figure 14) and you have a modified skull ready to go (Figure 15).

Smoke Test!

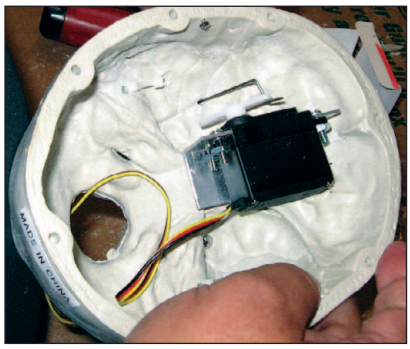
While some folks were busy modifying the skulls, the soldering area was in full swing (Figure 16). The first board was completed by Paul Atkinson (Figure 17) and we took it to the test area to try it out. We powered it up and uh, oh, the servo refused to budge! After a bit of head scratching, connection testing, and taking readings on the board using a meter and an oscilloscope (Figure 18), we found that two pads on the circuit board had a solder bridge. Once that was fixed, the board worked fine.

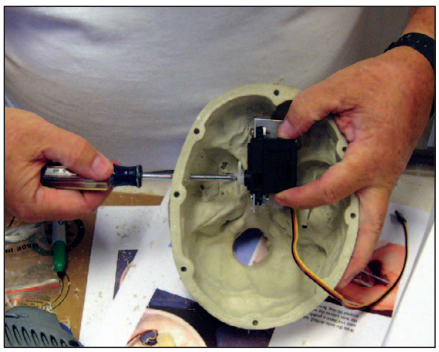
■ FIGURE 11. Zip ties used to create a hinge for the jaw.



■ FIGURE 12. Attaching the servo bracket to the skull.

■ FIGURE 13. Piano wire push-rod threaded through hole to jaw.





■ FIGURE 14. Tightening the servo horn on the servo.

■ FIGURE 15. Steven Reeves shows off his completed skull modification.

■ FIGURE 16. TXfx and Robot Group members soldering together printed circuit boards.

I then headed to the garage and got some additional lighting for the solder table. Lesson learned — good lighting is critical when working with small electronics! We tested each board as it was completed and with the exception of an inverted LED and a couple of other small solder mistakes, we were able to get a 100% success rate even on boards assembled by folks that had very little soldering experience.

Let's Give Them Something to Talk About!

So, now that we have a talking skull, we need something for it to say! To help get you started, there are some pre-made spooky and silly MP3 files with dialog and music/efx on separate channels available for download from the *Nuts & Volts* website (**www.nutsvolts.com**). These sound files can be loaded into an MP3 player or burned to an audio CD for use with the project. There are some corny jokes and some scary sounding haunted house rules, as well as other bits of dialog that can be fun to play through the skull. If you load all of them onto a player and then set it to random-play mode, your talking skull can chatter away through the evening with interesting and ever-changing fun dialog. Some folks like to use a pair of skulls and set one to respond to the left side audio and one to respond to the right side audio. They then hide a speaker behind or under each skull and play some back and forth dialog usually referred to as "Joking Skellies." This way, the two skulls carry on a conversation with each one responding to its own unique sound track.

Special Thank Yous

■ "Scary" Terry Simmons for his very cool servo audio board design and his generosity in sharing the design with all of us.

■ Carl Cowley of Cowlacious Designs for creating the Talking Skull kit and getting the kits sent to us in time for the Make and Take.

■ The TxFX members who came out and made the Make and Take so much fun.

■ Paul Atkinson of The Robot Group for being our #1 soldering guru.

■ Eric Lundquist of The Robot Group for troubleshooting, teaching, and testing.

■ Ed Gonzalez of The Robot Group for photography and tech assistance.

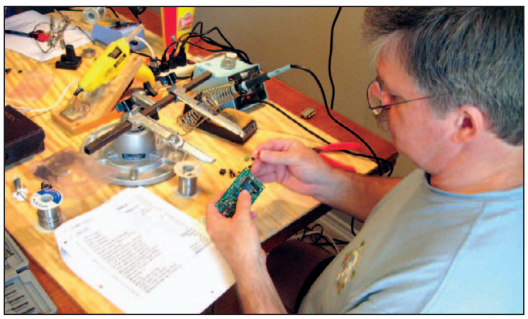
■ Hedstrom Music for some of the cool MP3 sound files!

■ And, last but not least, to my wife Kym for allowing us to wreck her kitchen for the weekend! Thanks Honey!

It is Remotely Possible

If downloading MP3s or burning CDs isn't to your liking, as an alternative you could use a standard FM radio to drive the audio servo board and an FM transmitter to make the talking skull say anything you like! Imagine placing the skull on the front porch and watching from your window as people approach. What? You don't have an FM transmitter? Well, as luck would have it, there's an FM transmitter kit featured in this month's issue of *Nuts & Volts* that is also available as a kit in the *Nuts & Volts* store. To learn about this cool kit, turn to page 40.

■ FIGURE 17. Paul Atkinson finishing the first ST-200b board.



■ FIGURE 18. Paul Atkinson uses an oscilloscope to troubleshoot the first board.

■ FIGURE 19. ST-200b kit mounted inside an animatronic "talking" Christmas present.

Applications

The talking skull is not only a fun item to have around, but the kit itself contains portions that should be interesting to many different hobbyists as it requires drilling, sanding, soldering, wiring, audio, and even a bit of robotics. Using the controls on the board, you should be able to adjust the skull to provide a very realistic sync with all kinds of different audio source. My daughter likes to put various pop-music CDs in the player and watch the skull sing with the voice of stars like Britney Spears or Hannah Montana. To see some videos of the finished talking skulls from our Make and Take, check out Resources for links.

Alternate Uses

If the audio servo kit is intriguing but seems like a one trick pony (or maybe you're just not into Halloween), remember that there are lots of other uses for this board. Instead of buying the skull kit, you could purchase just the board and servo motor for use in animating other props or puppets. The board is well suited to making a talking Santa Claus, a group of singing elves, a wise-cracking easter bunny, or a chatty Christmas present (Figure 19). It can be used anywhere you want to move an object in relation to an audio source.

Conclusion

That about wraps it up for this project. If you have any questions or if you would like to share your thoughts on the Talking Skull Kit, please stop by the *Nuts & Volts* forums where you can discuss projects, share pictures and videos, or get ideas from other builders. As always, if you have any questions or comments, feel free to send them to me at vern@txis.com. **NV**

Just in time for Halloween! The Talking Skull kit is available NOW in the *Nuts & Volts* online store! Visit **http://store.nutsvolts.com** to order yours today!

Resources

- Scary Terry's web page **www.scary-terry.com**
- The Robot Group **www.TheRobotGroup.org**
- Cowlacious Designs kit manuals **www.cowlacious.com/Support.htm**
- Videos of the Talking Skull system in action: **www.cowlacious.com/Scary_Terry_Vids.htm**
- TXFx group **http://groups.yahoo.com/group/TXfx/**
- Video from the Make and Take **www.youtube.com/user/VernGraner**
- *Nuts & Volts* Webstore **http://store.nutsvolts.com**
- Haunted MP3 files courtesy of Hedstrom Music: **www.hedstrom.net**