Virtual Author Talk

Make: Wearable Electronics

Kate Hartman

The author of the book "Make: Wearable Electronics" talks about how she became interested in the field and how costumers can master the skills to make their own creations.

Tell us about your background and how you became interested in this area.

Originally I studied Film and Electronic Arts at Bard College in New York where I started with 16mm film production and ended up developing a digital video and installation art practice. Several years later I decided to pursue a Master's degree at New York University's Interactive Telecommunications Program (ITP) in an effort to learn how to make my work more "interactive". It was there that I was first introduced to electronics and programming.

As I developed my skills in these areas I realized that my primary interest was in human interaction - both the beauty and the awkwardness of it. I realized that one way to approach interactive systems was to actually place them on the body so that they would move with them through the world. That's when I started making wearables.

In 2009 I moved to Toronto to join a faculty team that was founding the Digital Futures program at OCAD University, Canada's largest art and design school. My role was to help develop the wearables and physical computing curriculum for students coming from a diverse range of backgrounds. I also founded the Social Body Lab, a research and prototyping group dedicated to the exploration of body-centric technologies in the social context. Now our undergraduate and graduate programs are developed and launched, and I've been teaching about and making wearable electronics ever since.

What is the idea behind wearable electronics?

Wearable electronics is the practice of incorporating technology into clothing and other wearable forms. This can range from adding a few LEDs to a design for some visual flair, to incorporating an entire interactive system with a variety of sensors and actuators. Both fashion and costume design offer many opportunities for function and personal expression. The addition of electronics into those contexts simply enhances and extends those offerings.

Why did you decide to write this book?

I wrote *Make: Wearable Electronics* because during my years of teaching in this area, I found that there were no textbooks that specifically met my needs. At the time there were only a few e-textile books available, and while they were great, they didn't cover computation or interactivity in the way that I needed for my students. I always enjoyed *Physical Computing* by Dan O'Sullivan and Tom Igoe and was looking for the wearables equivalent of that.

My book essentially covers everything that I would in an introductory wearable computing course. I published it through Maker Media rather than a textbook publisher because I wanted it to be available

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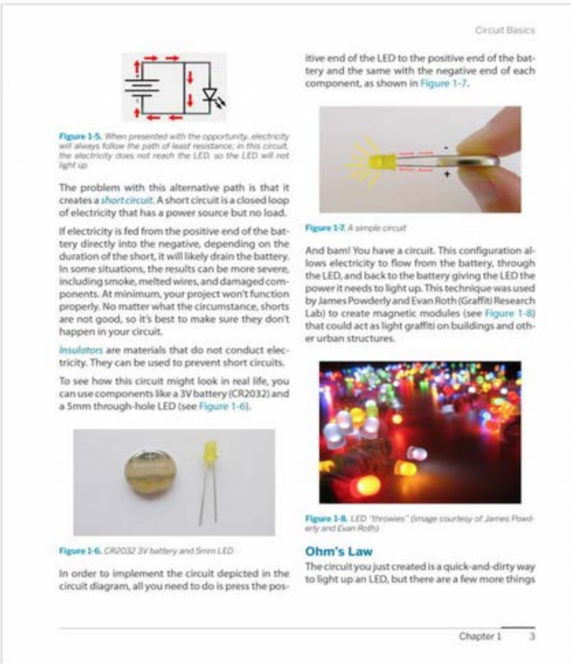
Circuit Basics

Figure 1-5. When presented with the opportunity, electricity will always follow the path of least resistance; in this circuit, the electricity does not reach the LED, so the LED will not light up

The problem with this alternative path is that it creates a *short circuit*. A short circuit is a closed loop of electricity that has a power source but no load.

If electricity is fed from the positive end of the battery directly into the negative, depending on the duration of the short, it will likely drain the battery. In some situations, the results can be more severe, including smoke, melted wires, and damaged components. At minimum, your project won't function properly. No matter what the circumstance, shorts are not good, so it's best to make sure they don't happen in your circuit.

Insulators are materials that do not conduct electricity. They can be used to prevent short circuits.

To see how this circuit might look in real life, you can use components like a 3V battery (CR2032) and a 5mm through-hole LED (see Figure 1-6).

Figure 1-6. CR2032 3V battery and 5mm LED

In order to implement the circuit depicted in the circuit diagram, all you need to do is press the positive end of the LED to the positive end of the battery and the same with the negative end of each component, as shown in Figure 1-7.

Figure 1-7. A simple circuit

And bam! You have a circuit. This configuration allows electricity to flow from the battery, through the LED, and back to the battery giving the LED the power it needs to light up. This technique was used by James Powderly and Evan Roth (Graffiti Research Lab) to create magnetic modules (see Figure 1-8) that could act as light graffiti on buildings and other urban structures.

Figure 1-8. LED "throwies" (image courtesy of James Powderly and Evan Roth)

Ohm's Law

The circuit you just created is a quick-and-dirty way to light up an LED, but there are a few more things

Chapter 1 3

to a broader audience, in terms of both cost and format.

I'm used to teaching people at a variety of educational levels. Even though I use the book in both undergraduate and graduate education, it is also suitable for a young adult, a weekend hobbyist, or just someone coming from a completely different field, like costuming. Wearable electronics is an important emerging field. I wanted to make this information as accessible as possible.

What areas of wearable electronics does the book cover?

The book covers everything from how to build a basic circuit using all kinds of neat materials (conductive thread, fabric, and others) to designing and programming with microcontrollers, all the way to wireless communication. It also covers the concept of "how to make something wearable" and includes example projects from talented artists and designers throughout the book.

Does working with wearable electronics require a very technical background?

No - you just need to be willing to learn about technical things. In my courses I often have students coming from a textile or jewelry background who tell me that they are "not technical". But when I look at the complexity of what they weave or solder it is evident that they are some of the more technical people I know. The good news is that due to the boom of the maker / do-it-yourself movement, resources for working

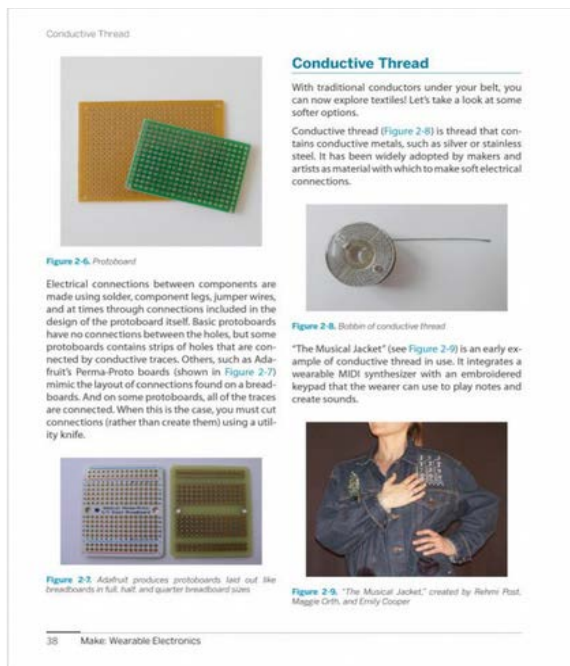
Conductive Thread

Figure 2-6. Protoboard

Electrical connections between components are made using solder, component legs, jumper wires, and at times through connections included in the design of the protoboard itself. Basic protoboards have no connections between the holes, but some protoboards contains strips of holes that are connected by conductive traces. Others, such as Adafruit's Perma-Proto boards (shown in Figure 2-7) mimic the layout of connections found on a breadboards. And on some protoboards, all of the traces are connected. When this is the case, you must cut connections (rather than create them) using a utility knife.

Figure 2-7. Adafruit produces protoboards laid out like breadboards in full, half, and quarter breadboard sizes

Conductive Thread

With traditional conductors under your belt, you can now explore textiles! Let's take a look at some softer options.

Conductive thread (Figure 2-8) is thread that contains conductive metals, such as silver or stainless steel. It has been widely adopted by makers and artists as material with which to make soft electrical connections.

Figure 2-8. Bobbin of conductive thread

"The Musical Jacket" (see Figure 2-9) is an early example of conductive thread in use. It integrates a wearable MIDI synthesizer with an embroidered keypad that the wearer can use to play notes and create sounds.

Figure 2-9. "The Musical Jacket," created by Rehmi Post, Maggie Orth, and Emily Cooper

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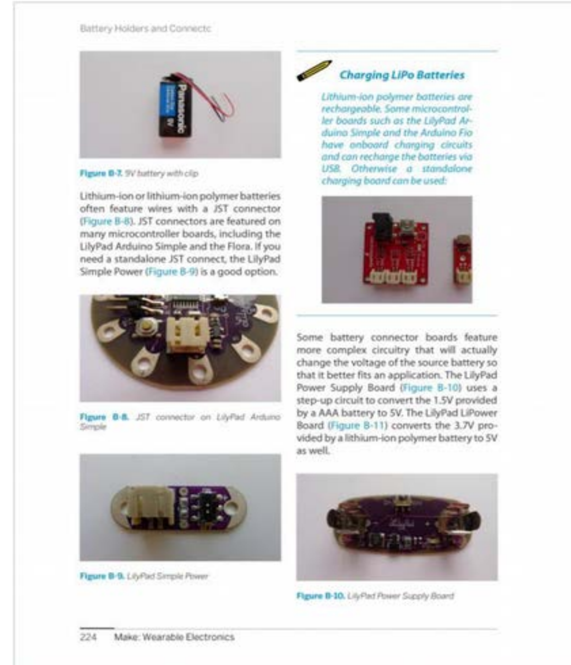
Battery Holders and Connectc

Figure B-7. 9V battery with clip

Lithium-ion or lithium-ion polymer batteries often feature wires with a JST connector (Figure B-8). JST connectors are featured on many microcontroller boards, including the LilyPad Arduino Simple and the Flora. If you need a standalone JST connect, the LilyPad Simple Power (Figure B-9) is a good option.

Figure B-8. JST connector on LilyPad Arduino Simple

Figure B-9. LilyPad Simple Power

Charging LiPo Batteries

Lithium-ion polymer batteries are rechargeable. Some microcontroller boards such as the LilyPad Arduino Simple and the Arduino Fio have onboard charging circuits and can recharge the batteries via USB. Otherwise a standalone charging board can be used:

Some battery connector boards feature more complex circuitry that will actually change the voltage of the source battery so that it better fits an application. The LilyPad Power Supply Board (Figure B-10) uses a step-up circuit to convert the 1.5V provided by a AAA battery to 5V. The LilyPad LiPower Board (Figure B-11) converts the 3.7V provided by a lithium-ion polymer battery to 5V as well.

Figure B-10. LilyPad Power Supply Board

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with both electronics and wearable electronics are abundant. I find that beginners benefit from starting with books because they are carefully edited and provide a cohesive linear structure. But once a baseline of knowledge is established there is a wealth of information to be pursued in the great beyond of the internet!

What features and projects in the book will especially interest costumers?

For costumers I would recommend starting with Chapter 8 - the Actuators chapter. Actuators are the things that DO things. If working with electronics is new to you, imagine how awesome it would be to incorporate light, sound, or motion into your costume design - a skirt that glows, wings that flap, a gauntlet that plays a sound effects or music! From there you can refer back to Chapter 6 to learn how to control your desired device with a micro controller.

If you want to get fancy you could incorporate some sensors (from Chapter 7) to control your desired effect using pressure, proximity, or even muscle activity! Once you have a vision of everything that might be included in your costume you could refer back to Chapter 2 to explore what kinds of conductive materials you could use to comfortably incorporate your circuitry into a wearable form.

Talk in a little more detail about a project that you especially enjoyed.

A few years ago I worked with my team at Social Body Lab to produce a piece

Resources

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Here are some additional resources that will help you learn where to shop, what to read, and where to learn.

Where to Shop

General electronics supplies:

- All Electronics
- Adafruit Industries
- Creatron Inc.
- Digi-Key
- Jameco
- Maker Shed
- Mouser Electronics
- Newark element14
- RadioShack
- Robotshop
- SparkFun Electronics
- Seeed Studio

Conductive materials:

- Bare Conductive Paint
- Fine Silver Products
- Lamé Lifesaver
- Less EMF
- Inventables
- Plug & Wear

Sewing gear:

- Jo-Ann Fabric and Craft Stores
- Seattle Fabrics
- The Felt Store

For Your Bookshelf

Whether you're looking for instruction or inspiration, these titles will enable you to expand upon and deepen your knowledge of the topics covered in this book:

- *Arduino Cookbook* by Michael Margolis (O'Reilly)
- *Arduino Wearables* by Tony Olsson (Apress)
- *Building Wireless Sensor Networks* by Robert Faludi (O'Reilly)

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called Monarch. This was developed in collaboration with Jamie Sherman, an anthropologist at Intel who was researching technologies that feel like a visceral extension of self. We worked to develop a muscle-activated kinetic textile - essentially a set of shoulder-based wings that raised and lowered as you flexed and released your bicep muscle.

Monarch project: a kinetic textile. Wings raise and lower by flexing and releasing biceps.

Beyond the satisfying interaction, what I really like about this project was the material development. We went through several iterations and came out with a piece that was constructed of laser cut leather, digitally printed textiles (to create the folded hyperbolic parabaloid shape that comprised the interior of the "wings"), custom printed circuit boards, and 3D printed motor attachments. The result has a refined look and is comfortable to wear. The electronics were even comfortably accommodated in a cavity of the wet moulded leather.

What is your advice to costumers who are just getting started in wearable electronics?

Try lots of things, get help, and don't get discouraged. Playing with electronics is just as fun as playing with other sorts of materials. Sometimes through messing around with these new materials, you'll learn and discover more than you expected. Getting started with electronics can sometimes seem overwhelming, but remember that if you're already making stellar costumes you're probably pretty smart and talented. Use books, the internet, and other humans to help get you over humps when you encounter them. And finally have fun with it! Wearable electronics is just another way you can express attitudes, ideas, and identities on the canvas of the human form.

***Kate Hartman** is an artist, technologist, and educator whose work spans the fields of physical computing, wearable electronics, and conceptual art. Her work has been exhibited internationally and featured by the New York Times, BBC, CBC, NPR, in books such as "Fashionable Technology" and "Art Science Now". She was a speaker at TED 2011 and her work is included in the permanent collection of the Museum of Modern Art in New York. Hartman is based in Toronto at OCAD University where she is the Associate Professor of Wearable & Mobile Technology and Director of the Social Body Lab. She is also the director of ITP Camp, a summer program at ITP/NYU. Hartman enjoys bicycles, rock climbing, and someday hopes to work in Antarctica.*