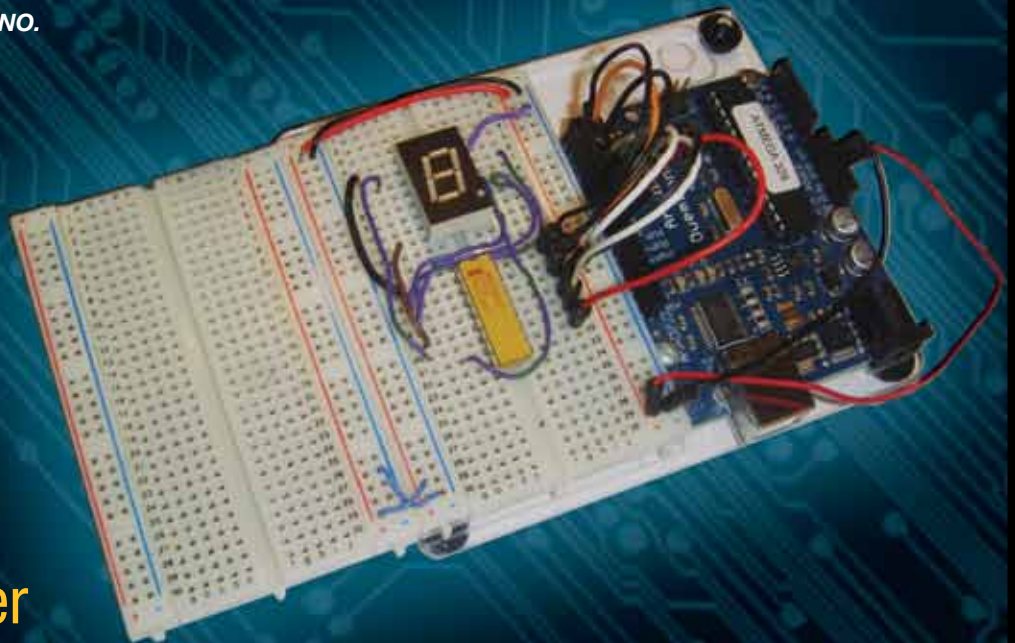




TECHNOLOGY IN ACTION™

Learn Electronics with Arduino

*LEARN ELECTRONICS CONCEPTS WHILE
BUILDING PRACTICAL DEVICES AND COOL
TOYS WITH ARDUINO.*



Don Wilcher

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Introduction

Have you ever wondered how electronic products are created? Do you have an idea for a new electronic gadget but no way of testing the feasibility of the device? Have you accumulated a junk box of electronic parts and now wonder what to build with them? Well, this book will answer all your questions about discovering cool and innovative applications for electronic gadgets using the Arduino. The book makes use of the Arduino plus discrete, integrated circuit components and solderless breadboards. Multisim software is used for circuit simulation and design equations.

Who Should Read This Book?

This book is for anyone interested in building cool Arduino electronic gadgets using simple prototyping techniques.

How This Book Is Structured

The chapters in this book are organized in such a way that the reader can choose to jump around the projects and discovery labs. Each chapter gives an introduction to the relevant key electronics components and supporting technologies. Also, each chapter explains the basic theory of operation of the electronic circuits with detailed circuit schematic diagrams. Build instructions with troubleshooting tips are included to help you detect and fix hardware/software bugs for each project. Last but not least, each chapter zooms in on a specific aspect of electronics technology followed by several semiconductor device-specific experiments. The experiments will help you understand the semiconductor device's electrical behavior as well as the setup of basic electronic test equipment and the Arduino software IDE tool via sketches.

You'll be introduced to circuit analysis techniques and the Discovery Method, which offers suggestions for further fun ways of learning about electronics technology. The goal of these hands-on activities is to encourage readers (whether inventors, engineers, educators, or students) to develop skills in engineering their own cool gadgets using simple prototyping techniques.

Downloading the Code

The code for the examples shown in this book is available on the Apress web site, www.apress.com. A link can be found on the book's information page under the Source Code/Downloads tab. This tab is located underneath the Related Titles section of the page.

Contacting the Author

Should you have any questions or comments—or if you spot a mistake—please contact the author at author@writing.com.

CHAPTER 1



Electronic Singing Bird

The Arduino is a small yet powerful computer board that uses physical computing techniques with an Atmel microcontroller (processing development environment) and the C programming language. To illustrate the versatility of the Arduino in turning ordinary electronic circuits into cool smart devices, I will show how to make an interactive electronic singing bird in this chapter. The required parts are pictured in Figure 1-1.

Parts List

Arduino Duemilanove or equivalent

0.047uF capacitor

0.1uF capacitor

470uF electrolytic capacitor

1 K resistor

50 K trimmer potentiometer

Audio transformer

2N3906 PNP transistor

2N3904 NPN transistor

5VDC relay

1 N4001 silicon diode

100Ω resistor

8Ω speaker

Cadmium sulfide (CdS) photocell

1 small solderless breadboard

22 AWG solid wire

Digital multimeter

Oscilloscope (optional)

Electronic tools

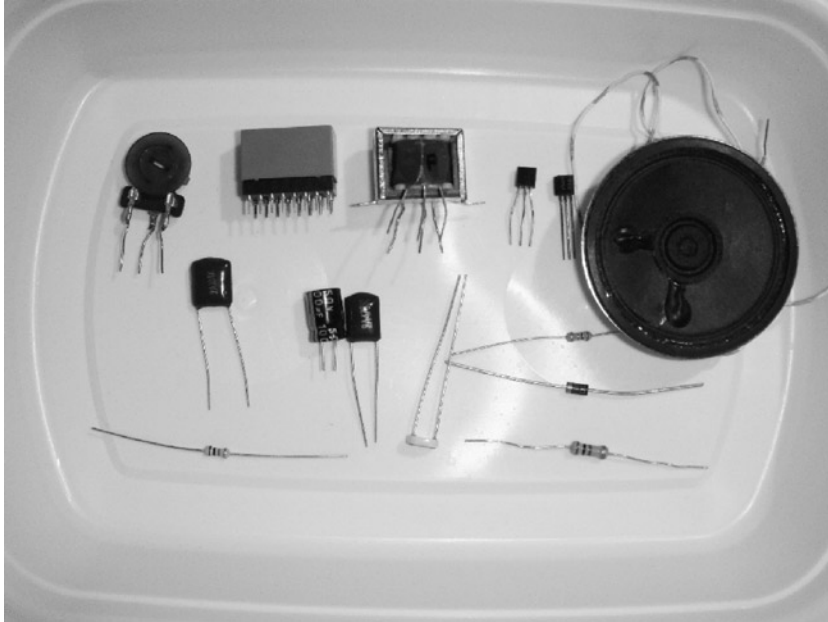


Figure 1-1. Parts required for the Arduino-based electronic singing bird

What Is Physical Computing?

The interaction between a human, an electronic circuit, and a sensor is *physical computing*. In this project I will demonstrate physical computing with an electronic singing bird. Placing a hand over the sensor allows the electronic circuit to produce a sound similar to a singing bird. Figure 1-2 shows a system block diagram of the mixed-signal circuit connected to an Arduino.

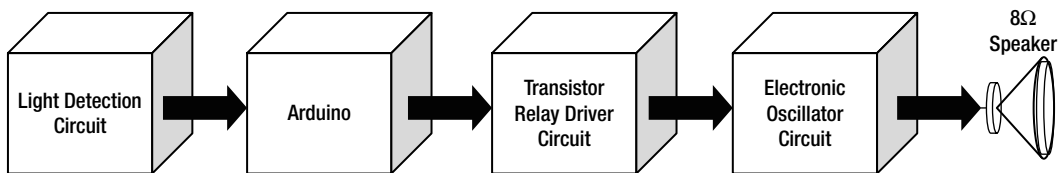


Figure 1-2. System block diagram for the electronic singing bird

■ **Note** An electronic oscillator is a circuit that produces a repetitive sine wave or square wave signal.

How It Works

The operation of the electronic singing bird starts with a cadmium sulfide (CdS) cell (photoresistor) detecting the absence of light. If no light is present, a voltage drop appears across the light-dependent resistor. The voltage across the CdS cell is approximately +2.5VDC, allowing the D2 pin of the Arduino to respond to the binary 1 logic signal. The software that is programmed into the Atmega328 microcontroller will turn on the D13 pin, making it switch from a binary 0 (0 V) to a binary 1 (+5VDC). With an output voltage of +5VDC, the transistor Q2 is able to turn on, allowing it to switch or energize the K1 relay coil. The iron core that is inside of the relay coil establishes a magnetic field attracting the electrical contact to the armature or common (COM) contact. The closing of the relay contacts will supply +5VDC to the electronic oscillator circuit. The chirping sound can be heard through the 8Ω speaker.

■ **Note** The ability to apply the appropriate voltage and current to the base of a transistor to turn it on is known as *biasing*.

Conducting a deep dive into the system block diagram reveals the circuit schematic diagram of the electronic singing bird shown in Figure 1-3.

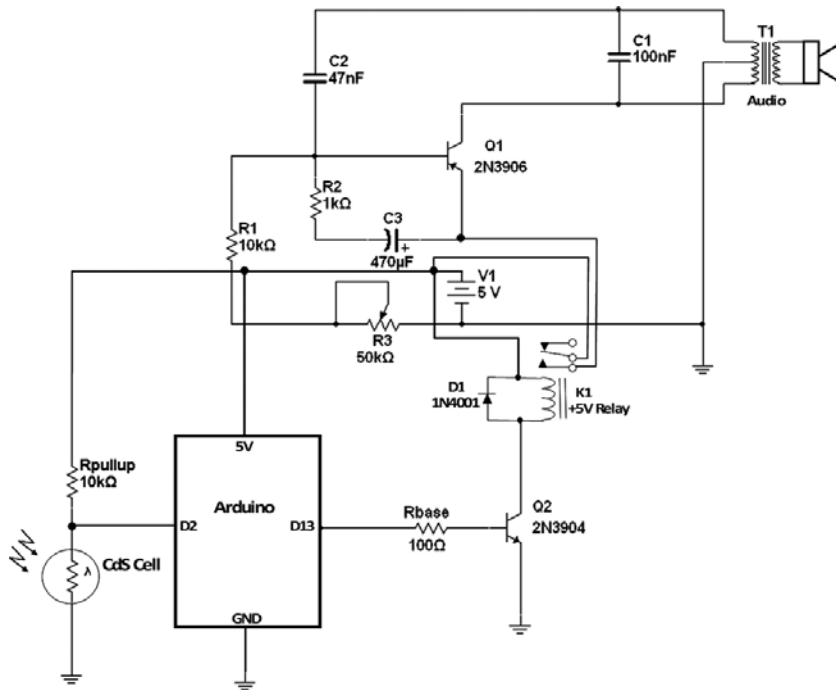


Figure 1-3. Schematic diagram for the electronic singing bird circuit

If you change the capacitance value of C3 (470 μ F), the electronic singing bird's tone duration will be affected. The smaller the capacitance value, the faster the time between bird chips heard through the 8 Ω speaker. The rheostat (50 K trimmer potentiometer) affects the switching time of the chirps. This control provides flexibility in terms of the type of chirp that can be heard through the 8 Ω speaker. The shape of the waveform is based on the 470 μ F capacitor charging from the +5VDC power supply and discharging through the 1 K resistor. This charging-and-discharging electrical behavior biases the 2N3906 PNP transistor, thereby allowing it to switch on and off at a repetitive rate. The series combination of resistors, consisting of a 10K fixed resistor and 50 K trimmer potentiometer, helps manage the switching time of the charging-and-discharging capacitor mentioned before. Capacitors C2 (47 nF) and C1 (100 nF) help reduce the switching noise peak voltage levels of C2. The pulse-generated signal is magnetically coupled to the 8 Ω speaker by the audio transformer. To further analyze the bird's electronic oscillator, I built a circuit model using Multisim software. Running a simulation event produced the output signal captured on a virtual oscilloscope, as shown in Figure 1-4.

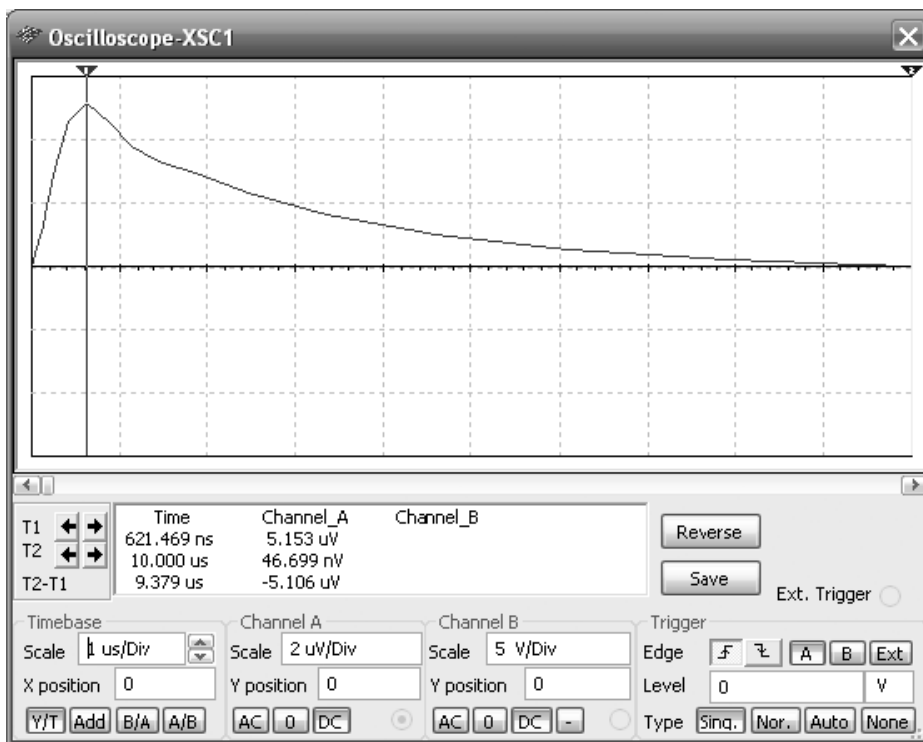


Figure 1-4. One cycle of a pulse wave captured on a Multisim virtual oscilloscope

■ **Note** Multisim is an intuitive software package capable of capturing circuit designs and testing electrical behaviors through simulation.

I was able to capture an actual pulsed waveform using an oscilloscope, as shown in Figure 1-5. The setup I used in capturing the pulsed signal is shown in Figure 1-6. The waveform has a frequency of approximately 1.2KHz, and it cycles approximately every 1 second. As mentioned earlier, the duration, or cycling, of the pulsed signal can be changed by adjusting the 50 K potentiometer.

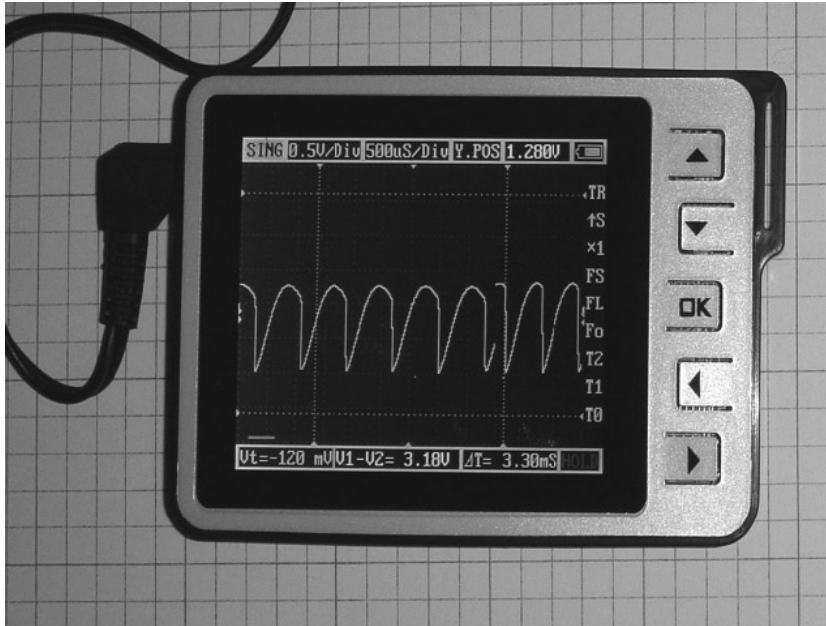


Figure 1-5. The pulsed waveform signal displayed on an oscilloscope

■ **Tip** Modeling electronic circuits using simulation software will provide baseline information on the electrical behavior of the target system. Sometimes the data obtained from a simulated model may be different from the actual circuit. As shown in Figure 1-4, the signal shows the rising edge of the waveform captured on the oscilloscope pictured in Figure 1-6. The rising edge of a waveform is the transition from 0V to the peak voltage (V_p).

The measurement setup was made by removing the 8Ω speaker from the secondary winding of the audio transformer and attaching an oscilloscope across it to capture the pulsed waveform signal. Figure 1-7 illustrates the measurement technique I used to capture the pulse waveform signal on the virtual oscilloscope. The signal is a derivation of a *pulse width modulation*, which is used in various electronic oscillators to create special-effect sounds.

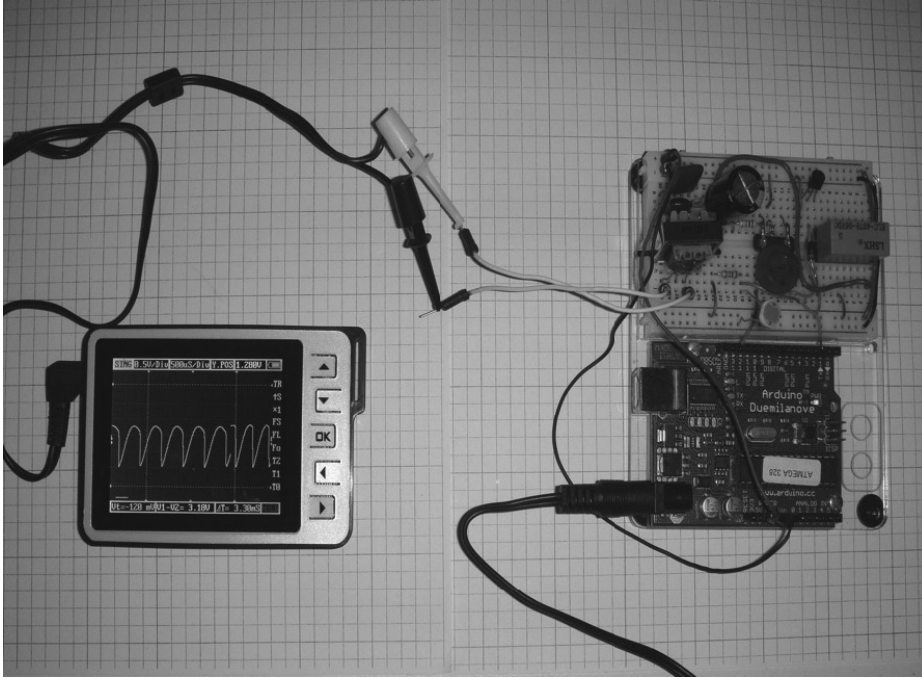


Figure 1-6. Test setup for displaying the pulsed waveform signal from the electronic oscillator circuit

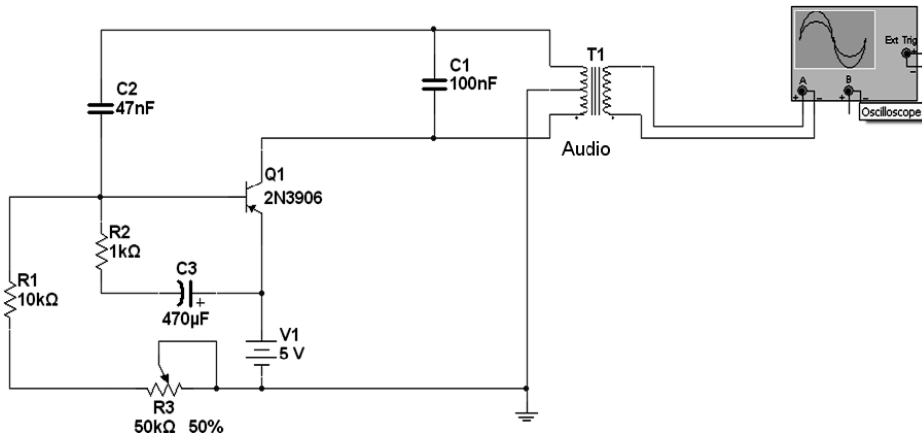


Figure 1-7. Circuit schematic diagram showing the oscilloscope attachment to the audio transformer for capturing a pulsed waveform signal