Using the Sound Board As an Analog-to-Digital Card

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Over the past few years, sound boards (or sound blaster cards) have become very inexpensive, and are standard items on most personal computers. Their primary use is for audio applications in multimedia and computer games. However, they can also serve as an analog-to-digital (A-to-D) card for data acquisition, and thus offer a very inexpensive way to interface computers with equipment in the laboratory, classroom, or at home. In fact, the line input to our sound board, Sound Blaster 16, is essentially a single-channel 8-bit A-to-D converter capable of sampling 22,000 times per second in direct mode. This data logger is hiding in many computers, and we describe here one way we have used ours.

Reading the sound card can be done with just a few lines of computer code. For example, we read our Sound Blaster 16 card with the following Pascal lines of code run in DOS:

```
port[$226] : = 1;    {reset the sound blaster}
delay(3);            {wait at least 3 microsec}
port[$226]: = 0;     {reset the port}
delay (100);         {wait at least 100 microsec}
for i: = 1 to 30000 do
  begin
   port [$22c]: = 32;    {initiate the A/D conversion}
   while port[$22e]<128 do;  {check to see if the
                              A/D is done}
   x[i]: = port[$22a];    {store the signal in an array}
end;
```

This program reads the sound card in direct mode 30,000 times in succession, with a sampling rate of 22,000 times per second for our card. Writing 32 (or 20h, which is a one in the fifth bit and zeros everywhere else) to port[$22c] initiates an 8-bit direct mode A-to-D conversion.

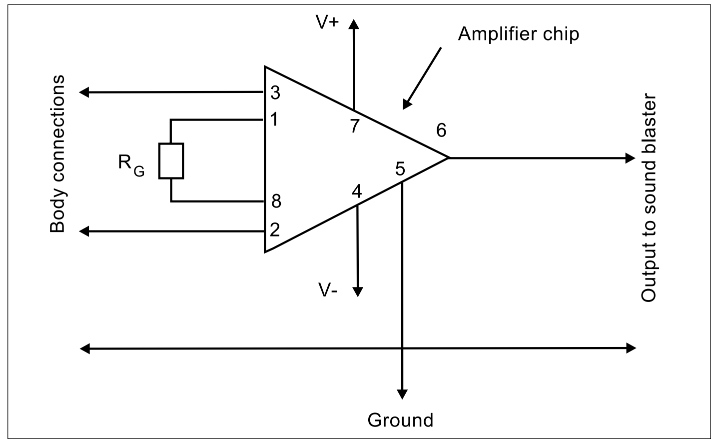

Fig. 1. Schematic of connections between subject, amplifier chip, and sound board for laboratory electrocardiogram.

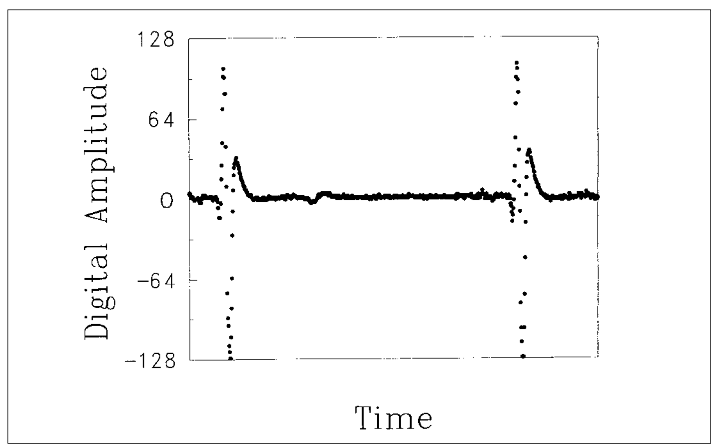

Fig. 2. Electrocardiogram signal from a volunteer. Time between two heartbeats is approximately one second. Vertical axis is the digitized signal from the sound board: port[$22a] – 127.

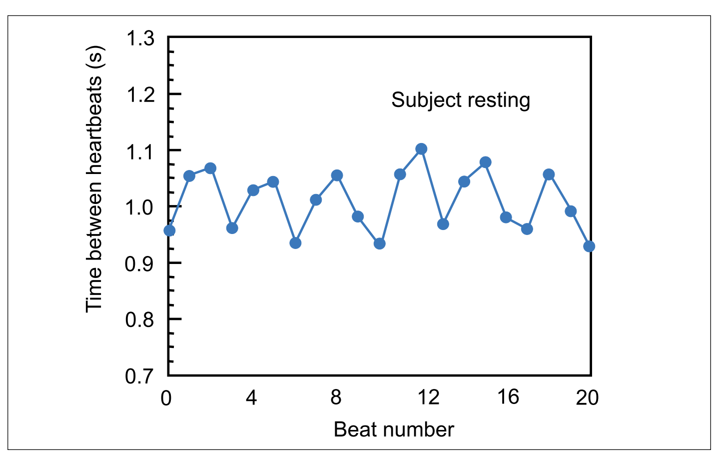

Fig. 3. Plot of time between heartbeats vs beat number for a volunteer at rest. Oscillations are due to breathing.

When the conversion is completed, the seventh bit in port[$22e] changes from zero to one. So when port[$22e] is greater than 127, the data can be read from port[$22a]. The actual voltage of the signal is equal to (port[$22a] – 127)*5/127. Input can be done via the line or microphone input on the card. The microphone input has a built-in amplifier, whereas the line does not. In the direct mode it is best to run the program in DOS, since in a Windows environment the sampling rate might not be uniform.

In one application, we use our personal computer as an electrocardiograph. This is done by putting the (amplified) electrical signal produced by the heart muscles into the line input of the sound card. We amplify the signal using a high-accuracy 8-pin instrumentation amplifier from Analog Devices, chip number AMP-02FP.[1] A schematic of how the amplifier chip is connected is shown in Fig. 1. The gain, G, of the amplifier is given by the formula $G = 50{,}000/R_G + 1$. We used a switch for three different values of R_G: 50Ω, 15Ω, and 5Ω, producing amplifications of 1000, 3333, and 10,000 respectively. A sample signal from a volunteer is shown in Fig. 2. The noise level is less than one percent.

This setup provides an inexpensive (under $50) electrocardiograph to be used for biology or biophysics laboratory experiments. For example, sampling the sound board in a loop enables one to measure the time between heartbeats very accurately, to one part in 20,000. In Fig. 3 we graph the time between heartbeats as a function of beat number. The oscillations are due to breathing. These variations can be used as an exercise in statistical analysis, and we find a large range in the percent variance of the times for a subject at rest. For certain individuals, the standard deviation of the time between heartbeats can be as low as 2% of the average time. For others it can be as large as 15%.

Thus, the sound board can be a useful A-to-D card in the laboratory. Not only can it be used to record the students' voices, but also lets them put their heart into their physics experiments.

Reference

1. We purchased the Analog Devices AMP-O2FP from Allied Electronics, 11030 Arrow Route, Suite 214, Rancho Cucamonga, CA 91730. Call 800-433-5700 for the closest branch office.

et cetera...

A Fundamental of Atmospheric Physics

"A basic understanding of weather and climate can be achieved by viewing the atmosphere as a giant heat engine with the Sun as the source of energy. The spherical shape of the Earth assures that the absorption of solar energy is not spatially uniform, which drives the atmosphere out of thermodynamic equilibrium and creates potential energy. Atmospheric motion is the manifestation of the conversion of available potential energy (created by unequal solar-energy input) to kinetic energy. In order to understand clearly how this happens, it is necessary to consider the physical laws of radiation, thermodynamics, and fluid motion."[1]

1. K.E. Kunkel, Am. Sci. **85,** *185 (March/April 1997).*

An Important Death

"Even within physics, I see an important death. Thermodynamics, essential to so much thinking in biology, is a dying language. It is still spoken in some areas of physics, but even there, more for cataloging than as the living language it was created to be.

"Somebody has to keep thinking carefully about heat, work, and energy."[1]

1. V. A. Parsegian, Phys. Today, July 1997, p. 24.

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