Apparatus Competition
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Remote Breathing Status Monitor

A. James Mallmann
Department of Physics and Chemistry
Milwaukee School of Engineering
1025 N Broadway
Milwaukee, WI 53202-3109

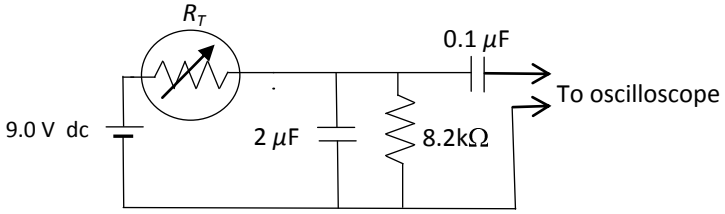
414-702-1842
mallmann@msoe.edu

Abstract

This apparatus uses a simple voltage divider circuit to produce an oscilloscope display that looks like a plot of the temperature of a person's inhaled and exhaled air versus time. The apparatus can be used in a classroom to demonstrate evidence for the exponential temperature dependence of the resistance of a semiconductor material and to show that the temperature of a small mass of such material can change quickly.

Construction of Apparatus:

The simple voltage divider circuit in the diagram at right can be used to produce an oscilloscope display that looks like a plot of a person's inhaled and exhaled air temperature versus time.



The component labeled R_T is a thermistor—the simplest of all semiconductor devices—with a room-temperature resistance of 10k-ohms (e.g. Jameco Electronics Cat. No. 1871852). The capacitor in parallel with the 8.2k-ohm resistor reduces noise in the waveform displayed on the oscilloscope screen.

The thermistor is located at the end of a 1.5 meter long cable to make it easy to hold it near the observer's mouth.

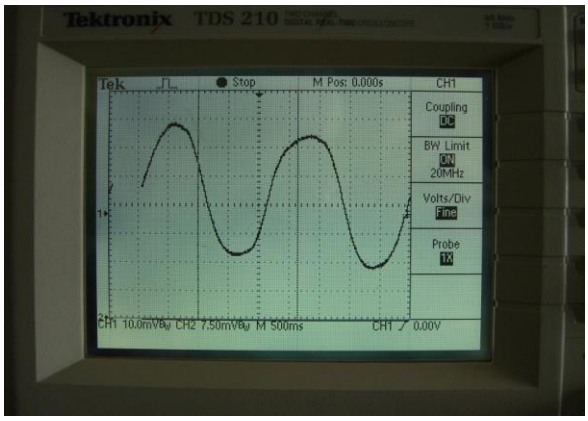
Use of Apparatus:

The air that a person *inhales* has the temperature of the air near the person. The *exhaled* air is significantly warmer. If the thermistor is placed at the location of the warm exhaled air the thermistor resistance will *decrease*, and the current through and the voltage across the 8.2k-ohm resistor will *increase*. When the cooler air is inhaled, the thermistor resistance will *increase* and the current through and the voltage across the 8.2k-ohm resistor will *decrease*. So when the voltage across the 8.2k-ohm resistor is displayed versus time on the oscilloscope screen, the waveform looks like a plot of inhaled and exhaled air temperature versus time. The small size and mass of the thermistor make possible rapid changes in its temperature and resistance.

The educational value associated with construction and use of this apparatus involves:

- Ohm's law
- an application that uses a thermistor—the simplest of all semiconductor devices
- a voltage divider circuit with a thermistor for one of the resistors
- signal processing
- the temperature dependence of the electrical conductivity of a semiconductor material
- the effect on electrical conductivity of thermally produced electron-hole pairs
- the exponential temperature dependence of the resistance of a sample of semiconductor material: $R = Ae^{B/T}$
- the small thermal inertia of a small mass of material
- the use of an oscilloscope
- an application of elementary principles to a practical application.

Because the oscilloscope display can be used to provide convincing evidence that a person is breathing—or *not* breathing—this simple system could be used for remote monitoring of the breathing status of a patient in the intensive care unit of a hospital.



Hold the thermistor near your open mouth while you inhale and exhale to produce an oscilloscope display similar to that in the photo above.