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StudentZone—Activity: Differential Temperature Sensor

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Objective

The objective of this lab activity is to design a differential temperature sensor circuit using diodes.

Background

A diode's forward voltage drop, V_D, decreases by approximately 2 mV for each 1°C increase in temperature, assuming a constant current in the diode. The circuit shown in Figure 1 uses this property as the basis of a crude differential temperature sensor. It is best if the diodes are of the same type and ideally from the same manufacturer. Both diodes are forward-biased, using equal resistor values to establish the same current, at least when the diodes are at the same temperature. Diode D_{SENSE} serves as the temperature sensor, while diode D_{REF} serves as the temperature reference maintained at a constant temperature—say, at room temperature (25°C), which is convenient. The difference in diode voltages V_{TEMP} is consequently proportional to the difference in temperature.

Materials

- ADALM2000 active learning module
- Solderless breadboard
- Two 1 kΩ resistors
- Two small signal diode (1N914 or similar)

Directions

Construct the circuit of Figure 1 using two 1N914 diodes.

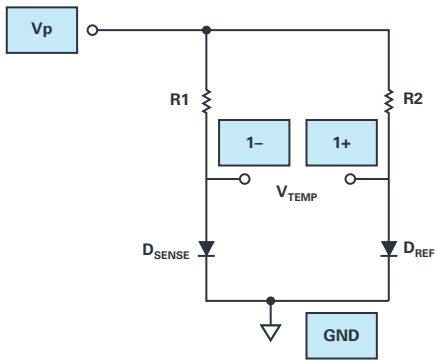

Figure 1. Differential temperature circuit.

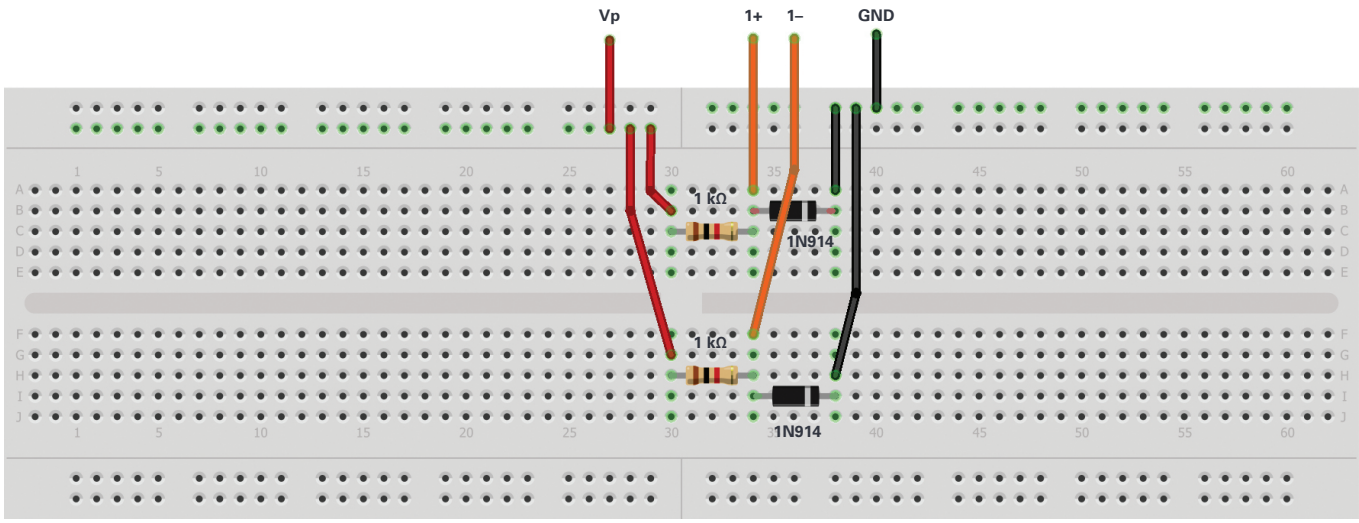

Figure 2. Differential temperature breadboard circuit.

Hardware Setup

Connect scope input 1+ to the positive terminal of V_{TEMP} and connect scope input 1– to the negative terminal of V_{TEMP}. Use scopy voltmeter or oscilloscope instruments to monitor the value of V_{TEMP} using the **True RMS** measurement display. Use auto-range for the voltmeter or set the **Volts/Div** scale for the oscilloscope to its most sensitive value (10 mV) and ensure that Channel 1 is enabled. Connect Vp to the 5 V power supply.

Procedure

Step 1

Allow both diodes to reach the same temperature: $T_{SENSE} = T_{REF}$. Measure and record the voltage offset as T_{AMP} set; subtract this offset voltage from your later measurements.

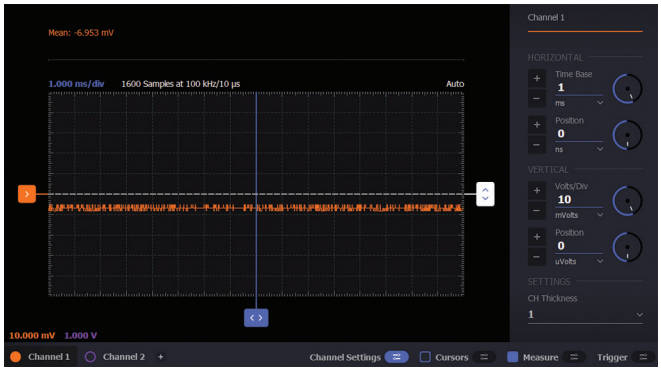

Figure 3. $T_{SENSE} = T_{REF}$ differential temperature waveform.

Step 2

Heat the sensor diode by squeezing it between your fingers. Wait for the voltage to stabilize, subtract V_{TEMP} set, and then record this value as the *body temperature* voltage. You might also try blowing through a straw to direct your warm breath at the sensor diode.

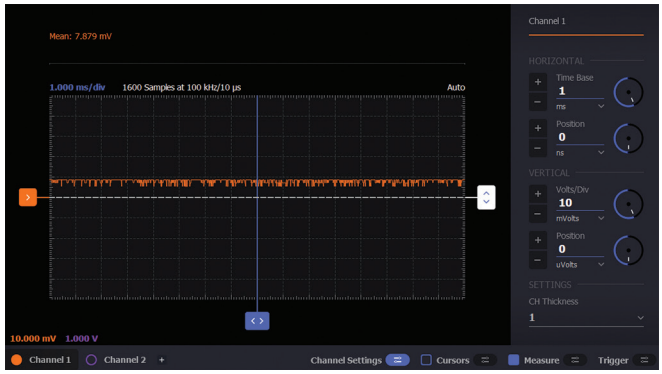

Figure 4. $T_{SENSE} > T_{REF}$ differential temperature waveform.

- If available, wrap the sense diode in a thin plastic bag and submerge it in ice water to chill the sensor diode. Again, wait for the voltage to stabilize, subtract V_{TEMP} set, and then record its value as the *freezing point of water* voltage.
- Determine the sensitivity of the temperature sensor output V_{TEMP} in millivolts per °C.

Questions

- Can you derive the sensitivity in mV/°C you measured from the diode equation?
- What is the purpose of the reference diode in this configuration?

You can find the answer at the StudentZone blog.

About the Author

Doug Mercer received his B.S.E.E. degree from Rensselaer Polytechnic Institute (RPI) in 1977. Since joining Analog Devices in 1977, he has contributed directly or indirectly to more than 30 data converter products and he holds 13 patents. He was appointed to the position of ADI Fellow in 1995. In 2009, he transitioned from full-time work and has continued consulting at ADI as a Fellow Emeritus contributing to the Active Learning Program. In 2016 he was named Engineer in Residence within the ECSE department at RPI.He can be reached at *doug.mercer@analog.com*.

About the Author

Antoniu Miclaus is a system applications engineer at Analog Devices, where he works on ADI academic programs, as well as embedded software for Circuits from the Lab®, QA automation and process management. He started working at Analog Devices in February 2017 in Cluj-Napoca, Romania. He is currently an M.Sc. student in the software engineering master's program at Babes-Bolyai University and he has a B.Eng. in electronics and telecommunications from Technical University of Cluj-Napoca. He can be reached at *antoniu.miclaus@analog.com*.