

AnalogDialogue

StudentZone– ADALM2000 Activity: A Floating (2-Terminal) Current Source/Sink

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Objective

The objective of this activity is to investigate the ΔV_{BE} concept to produce an output current that is stabilized (less sensitive) to variations of the input voltage level. Feedback is used to build a circuit that produces a constant or regulated output current over a range of supply voltages.

Materials

- ADALM2000 Active Learning Module
- Solderless breadboard
- One 500 Ω variable resistor, potentiometer
- One 100 Ω resistor
- Three small signal NPN transistors (2N3904)
- Three small signal PNP transistors (2N3906)

Directions

Build the circuit shown in Figure 1 on your solderless breadboard. The blue boxes indicate where to connect the ADALM2000. PNP transistors Q1, Q2, and Q3 form a current mirror with a gain of 2; the output current is twice the input current. NPN transistors Q4, Q5, and Q6 along with variable resistor R1 form the ΔV_{BE} part of the circuit. Resistor R2 is used to measure the current flowing in the circuit (Scope Channel 2) as the voltage across the circuit changes (Scope Channel 1).



Figure 1. Floating current source (as a sink tied to a negative supply).

The output current is set by R1. The difference in V_{BE} (Δ V_{BE}) between Q4 and the parallel combination of Q5 and Q6 appears across R1. The PNP mirror—Q1, Q2, and Q3—has a gain of 2, if we assume they are of identical size. Thus, the current in Q4 is twice the combined current of Q5 and Q6. Again, if we assume Q4, Q5, and Q6 are also identical in size, the current density ratio is 4, and the difference in V_{BE} will be:

$$\Delta V_{BE} = \frac{kT}{q} \ln 4 \tag{1}$$

Because of the absolute temperature term in this equation, the current will be proportional to absolute temperature. This can be a useful characteristic in certain instances but undesirable in others.



Figure 2. Floating current source (as a sink tied to a negative supply) breadboard circuit.

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Hardware Setup

Breadboard connections for the circuit are presented in Figure 2.

Procedure

Configure waveform generator W1 as a triangle wave with a frequency of 100 Hz and an amplitude of 10 V p-p with 0 V offset. The scope display should be set in both voltage vs. time and in XY mode with Channel 1 on the horizontal axis and Channel 2 on the vertical axis. Be sure to turn on the power supply only after you have completed and double checked your connections.



Figure 3. Floating current source (as a sink tied to a negative supply) Scopy XY plot example.



Figure 4. Floating current source (as a sink tied to a negative supply) LTspice XY plot example using ideal components.

Prove the Floating Nature of the Circuit

In Figure 1 we referenced the negative end of the circuit to a negative power supply. To prove that this circuit is truly a floating current source, rearrange your breadboard to look like Figure 5 and repeat your measurements.



Figure 5. Floating current source (as a source tied to a positive supply).



Figure 6. Floating current source (as a sink tied to a positive supply) breadboard circuit.

Hardware Setup

Breadboard connections for the circuit are presented in Figure 6.

Procedure

Configure waveform generator W1 as a triangle wave with a frequency of 100 Hz and an amplitude of 10 V p-p with 0 V offset. The scope display should be set in both voltage vs. time and in XY mode with Channel 1 on the horizontal axis and Channel 2 on the vertical axis. Be sure to turn on the power supply only after you have completed and double checked your connections.



Figure 7. Floating current source (as a sink tied to a positive supply) XY plot.



Figure 8. Floating current source (as a sink tied to a positive supply) LTspice XY plot example using ideal components.

Question:

What is the minimum voltage that the current source needs across it to maintain a more or less constant current, by analyzing the LTspice[®] plots for the circuits?

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@analoq.com.



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