EL 351 - Linear Integrated Circuits Laboratory

OP-AMP DC PARAMETERS DETERMINATION

By: Walter Banzhaf
University of Hartford
Ward College of Technology
USA

Equipment:

- Agilent 54622A Deep-Memory Oscilloscope
- Agilent E3631A Triple-Output DC power supply
- Agilent 33120A Function Generator
- Agilent 34401A Digital Multimeter

Introduction:

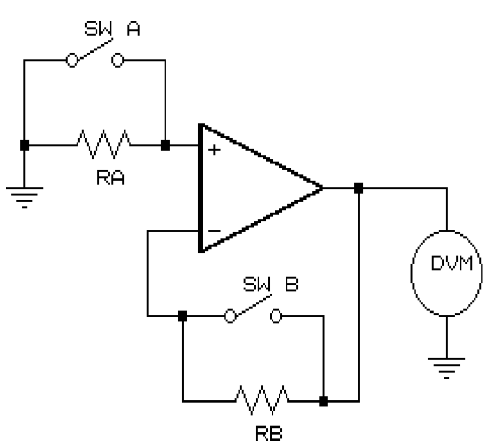
The DC characteristics of input offset voltage (Vio), input bias current (IB), input offset current (Iio), output voltage swing, supply currents and output short circuit currents are important characteristics of an op-amp, since they must be known to analyze or design a circuit using that op-amp. In this lab experience, you will measure some of the DC parameters of a BJT-input operational amplifier (a 741). Also, you will measure input bias currents and input offset voltage for a FET-input op-amp, and compare these values with those of the 741.

The techniques used in this experiment are universally applicable to most op-amps; the specific parts values used in the tests, however, may have to be varied (by you) depending on the type of IC (BJT, JFET, MOSFET, precision) under test.

I. Measuring Vio and I_B

Be sure to apply power to circuits for enough time (about 5 minutes from a cold start), to allow chip temperature to stabilize before taking data.

1. Construct the circuit below:



V_{supply} = +/- 15 VDC.

Pick R_A and R_B somewhere between 2M and 10M Ω. They need NOT be matched, or even equal.

Use jumper wires for switches A & B.

MEASUREMENT OF INPUT OFFSET VOLTAGE (Vio)

2. With both switches closed, record V_o. This voltage is V_{oot} (total output offset voltage), which is the sum of V_{oo} (output offset voltage due solely to input offset voltage) and V_{oIB} (the output offset voltage due to input bias currents). However, V_{oIB} is zero since there is no resistance in the circuit through which input bias currents flow, so no voltage is created by the input bias currents.

It is possible (but not likely) that your op-amp had such a small V_{io} that either you could not measure it, or could not measure it with any precision. For example, a reading of 0.2 mV, as with any digital reading, is + or - 1 least significant digit. This means that the actual voltage could have been 0.1 mV or 0.3 mV, and the DVM could have displayed the same 0.2 mV value. This is a huge possibility for error. A more precise measurement of V_{io} will be done in step 7 below.

MEASUREMENT OF INPUT BIAS CURRENTS, USING RESISTORS

3. Open switch A and record V_o. This voltage is V_{oot}, which includes V_{oo}. Subtract the value of V_{oo} obtained in step 2, and the difference is V_{oIB}. Now calculate I_{B1} by using:

   $I_{B1} = -(V_{oot} - V_{oo})/R_A = -(V_{oIB})/R_B$.

4. Open switch B and record V_o. This voltage is V_{oot}, which includes V_{oo}. Subtract the value of V_{oo} obtained in step 2, and the difference is V_{oIB}. Now calculate I_{B2} by using:

   $I_{B2} = +(V_{oot} - V_{oo})/R_B = +(V_{oIB})/R_B$.

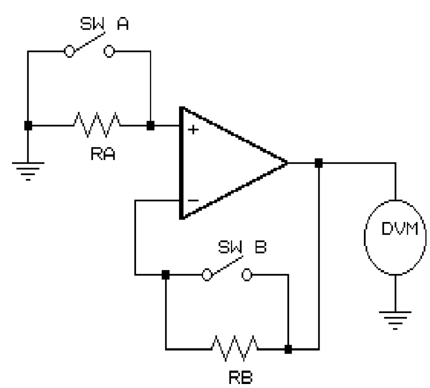
MEASUREMENT OF INPUT BIAS CURRENTS, USING A PICOAMMETER

5. A picoammeter is a DC current meter designed to measure currents with a resolution of 1 pA (1E-12 amperes). Remove R_A and R_B from the circuit above. Use a picoammeter to measure I_{B1} by putting its common lead to ground, and its "hot" lead to the non-inverting terminal, and removing the switch A jumper. Replace the switch A jumper after measurement.

6. Use the picoammeter to measure I_{B2} by putting its common lead to the op-amp output terminal, and its "hot" lead to the inverting terminal, and removing the switch B jumper.

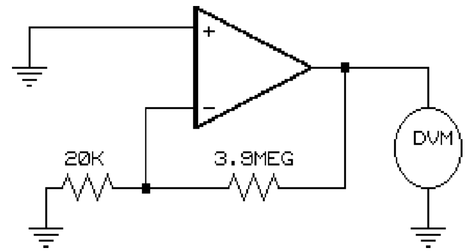
PRECISE MEASUREMENT OF INPUT OFFSET VOLTAGE

7. Construct the circuit shown below and record V_o. This voltage is V_{oot}, which is primarily V_{oo}, since the feedback resistance is quite small and error voltages at the output due to input bias current effects are negligable. An accurate and precise value of V_{io} can now be calculated by $V_{io} = V_o/(1 + R_2/R_1)$. Compare this value of V_{io} with the one you obtained in step 2.



MEASUREMENT OF TOTAL OUTPUT OFFSET VOLTAGE

8. Build the circuit below:



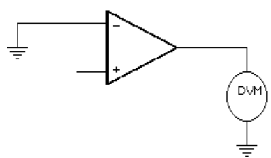
9. Record V_o, which is V_{oot}. There are significant contributions to this total output offset voltage from both V_{oIB} and V_{oo}.

10. Outside of lab, using the measured values of V_{io} and I_{B2} from parts 7 and 6, respectively, calculate the expected V_{oot} for the circuit. Compare the calculated V_{oot} with the measured V_{oot} from step 9.

11. Repeat steps 2, 5, 6 and 7 for an LF 351 op-amp, a JFET-input version of the 741.

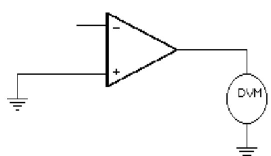
II. Measuring Saturation Voltages, Supply Currents & Output Short Circuit Currents, 741:

1. Build: Record:



$V_o = -V_{sat}$=___________

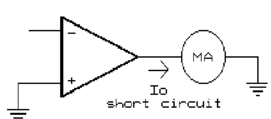
2. Build: Record:



$V_o = +V_{sat}$= __________

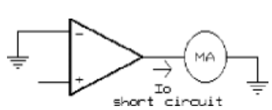
NOTE: in procedures 3 and 4 below, make sure you are measuring the short circuit current limit value **of your IC**, not the current limit setting **of your power supply!**

3. Build: Record:



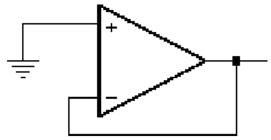
$I_{o(s.c.)}$ = ______________

4. Build: Record:



$I_{o(s.c.)}$ = ______________

5. Build: Record the +/- 15 V power supply currents



I_{CC} = ______________

I_{EE} = ______________

QUESTIONS

1. In I.3 why did V_o become negative? Could it just a likely have become positive if another IC were tested?

2. In I.4 why did V_o become positive? Could it just a likely have become negative if another IC were tested?

3. What were the values of input offset current for your 741 & LF 351 op-amps?

4. How could the total output offset voltage, V_{oot}, have been reduced in part I.9, if the op-amp used and the circuit voltage gain stayed the same?

5. Present, in tabular form, how each parameter of your 741 compared with manufacturer's typical specifications.

   Use this tabular format in your report. For comparisons, use

   [(measured value - typical value)/typical value] x 100%

PARAMETER	Manufacturer's Typical Value	Measured Value	Comparison
V_{io}			
I_B			
I_{io}			
Output Voltage Swing			
Vcc Supply Current			
Vee Supply Current			
Output Short Circuit Current			