National Aviation University

Department of Electronics, Robotics, Monitoring and IoT Technologies

Course: "Analog and Digital Instrumentation"

Experiment 8

"Instrumentation Amplifier"

Prepared by prof. V. Ulansky

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OBJECTIVES

1. To construct instrumentation amplifier using TINA-TI SPICE-based simulation program.
2. To simulate the operation instrumentation amplifier using TINA-TI simulation program.
3. To simulate voltages and currents in all nodes and branches of the circuit.

EQUIPMENT

1. Digital multimeter
2. Oscilloscope
3. Sinusoidal voltage generator
4. Power Supply
5. 3 operational amplifiers
6. Resistors: 2 × 1 kΩ, 1 × 100 kΩ, 2 × 2 kΩ

Theory

Instrumentation amplifier is a type of differential amplifier that has been outfitted with input buffer amplifiers, which eliminate the need for input impedance matching and thus make the amplifier particularly suitable for use in measurement and test equipment [1]. Additional characteristics include very low DC offset, low drift, low noise, very high open-loop gain, very high common-mode rejection ratio, and very high input impedances. Instrumentation amplifiers are used where great accuracy and stability of the circuit both short and long-term are required. Although the instrumentation amplifier is usually shown schematically identical to a standard operational amplifier (op-amp), the electronic instrumentation amp is almost always internally composed of 3 op-amps. These are arranged so that there is one op-amp to buffer each input (+,−), and one to produce the desired output with adequate impedance matching for the function.

The most commonly used instrumentation amplifier circuit is shown in Fig. 1. The gain of the circuit is

$$A_v = \frac{V_{\text{out}}}{V_2 - V_1} = \left(1 + \frac{2R_1}{R_{\text{gain}}}\right)\frac{R_3}{R_2}$$

The rightmost amplifier, along with the resistors labeled R_2 and R_3 is just the standard differential amplifier circuit, with gain = R_3/R_2 and differential input resistance = $2 \cdot R_2$. The two amplifiers on the left are the buffers. With R_{gain}

removed (open-circuited), they are simple unity gain buffers; the circuit will work in that state, with gain simply equal to R_3/R_2 and high input impedance because of the buffers. The buffer gain could be increased by putting resistors between the buffer inverting inputs and ground to shunt away some of the negative feedback; however, the single resistor R_{gain} between the two inverting inputs is a much more elegant method: it increases the differential-mode gain of the buffer pair while leaving the common-mode gain equal to 1. This increases the common-mode rejection ratio (CMRR) of the circuit and also enables the buffers to handle much larger common-mode signals without clipping than would be the case if they were separate and had the same gain. Another benefit of the method is that it boosts the gain using a single resistor rather than a pair, thus avoiding a resistor-matching problem, and very conveniently allowing the gain of the circuit to be changed by changing the value of a single resistor. A set of switch-selectable resistors or even a potentiometer can be used for R_{gain}, providing easy changes to the gain of the circuit, without the complexity of having to switch matched pairs of resistors.

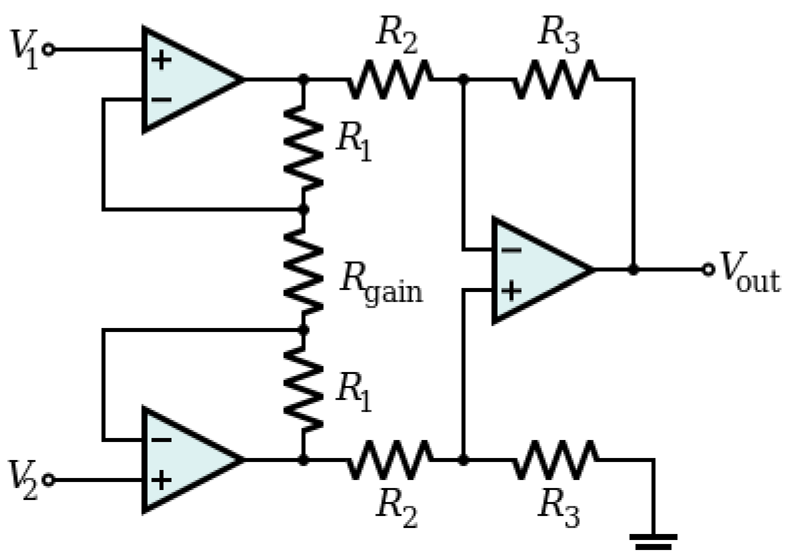

Fig. 1 Instrumentation amplifier

PROCEDURE

1. Construct the circuit of the instrumentation amplifier shown in Fig. 1.

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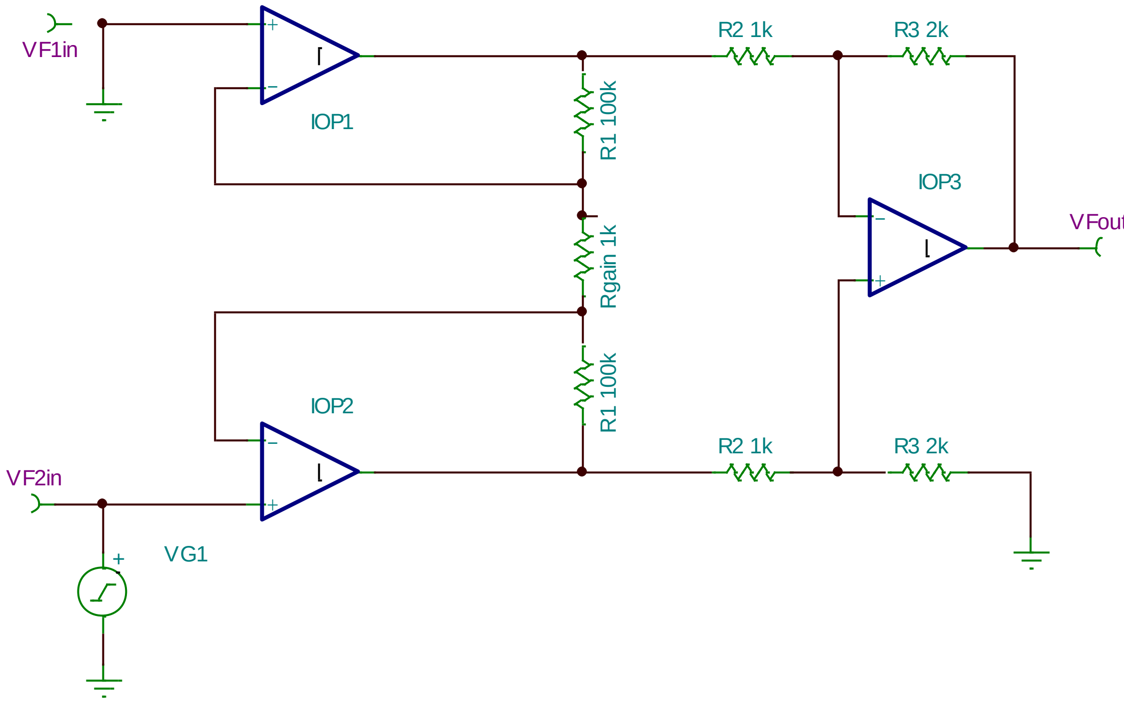
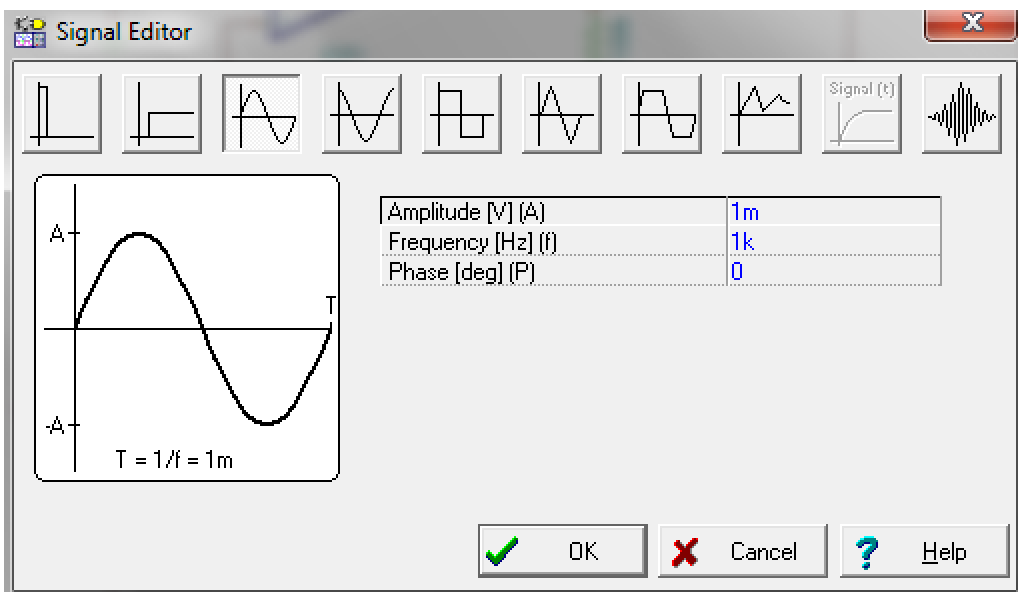
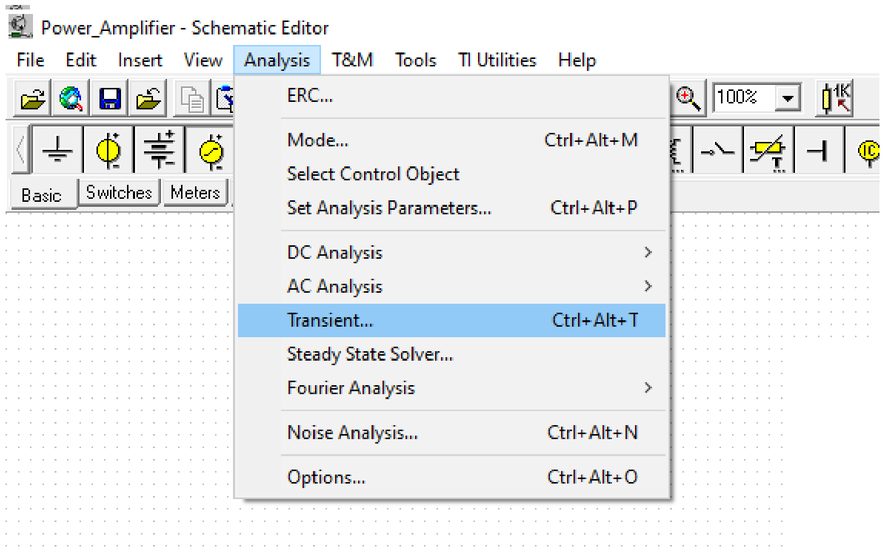


Fig. 2 Instrumentation amplifier constructed in TINA-TI

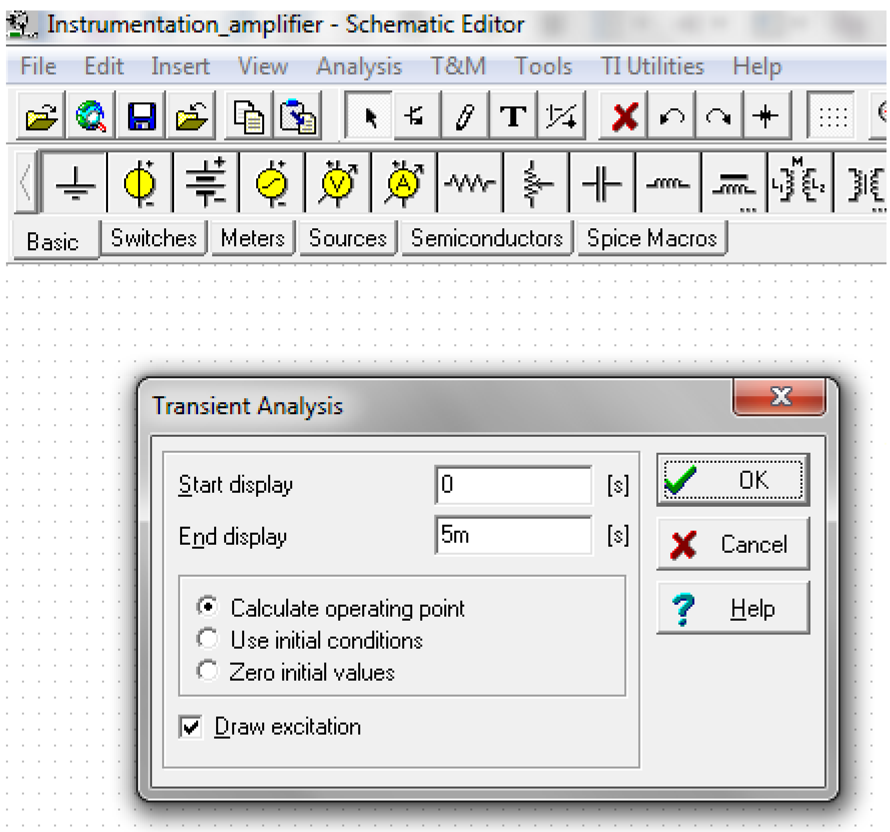
2. Select sinusoidal voltage generator (1 mV, 1.0 kHz) as shown below.



3. Select transient mode as shown below.



4. Choose Start display and Stop display time-points.



5. Press the buton OK and display the input and output waveforms of the amplifier as shown in Fig.

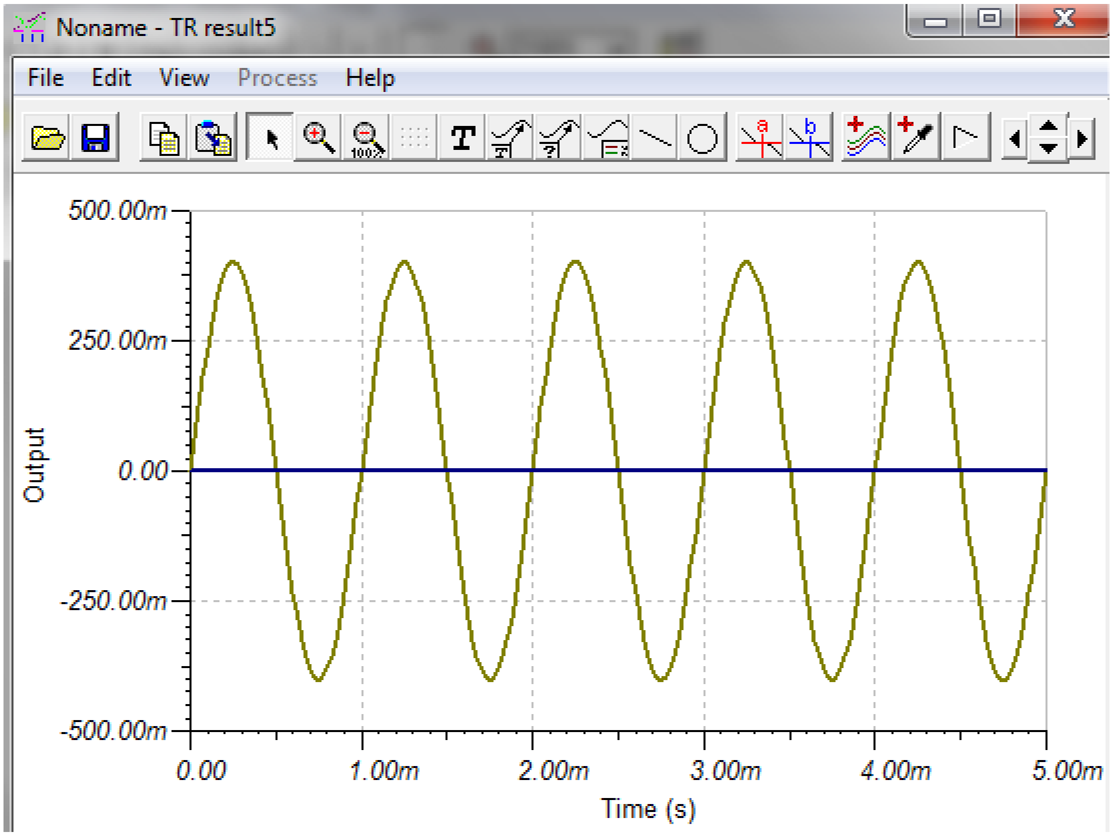
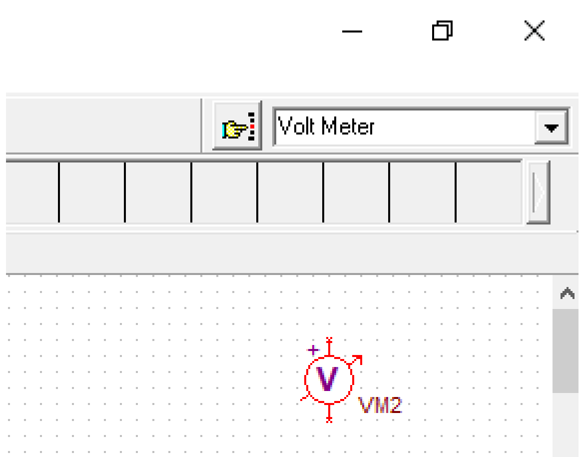


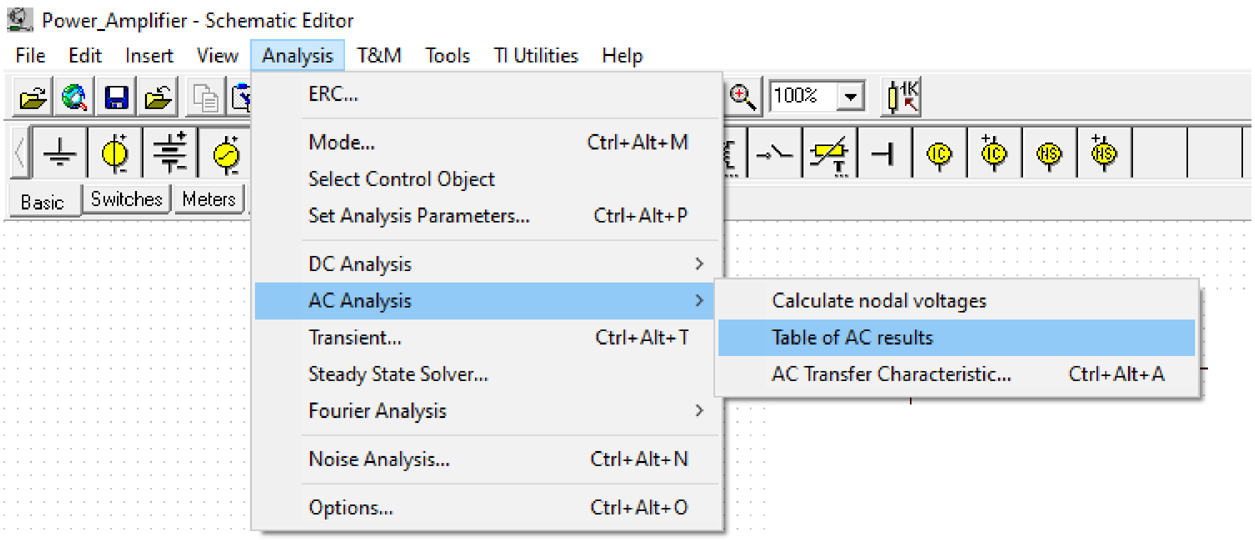
Fig. 3. Input and output waveforms of the instrumentation amplifier.

6. Select voltmeter as shown below.



7. Connect voltmeter at the output as shown in Fig. 4.

8. Select AC analysis as shown below.



9. Analyze nodal voltages and branch currents in the table of Fig. 4.

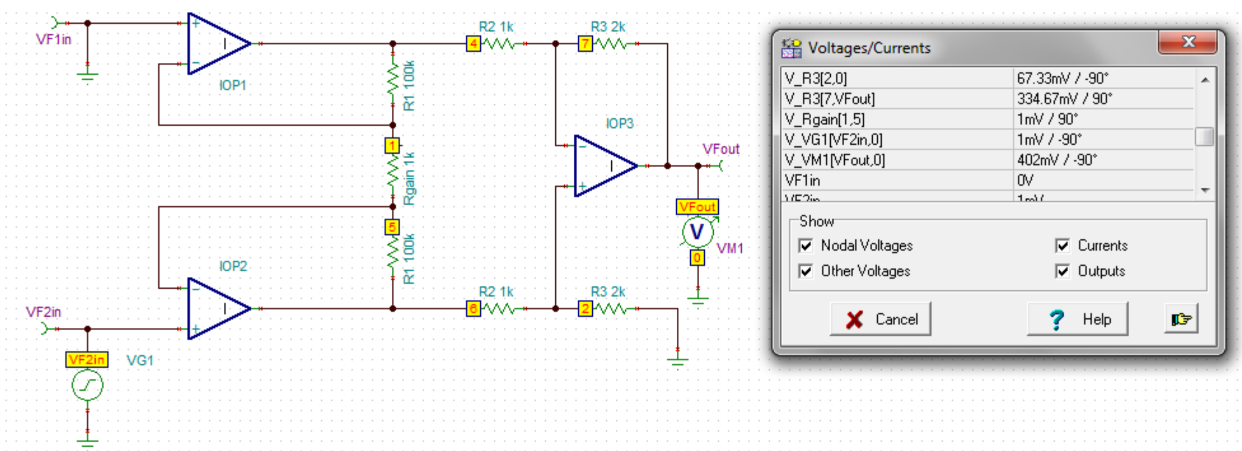


Fig. 4. Displayed nodal voltages.

11. Calculate the voltage and current gain of the amplifier.

Reference

1. https://en.wikipedia.org/wiki/Instrumentation_amplifier

2. A.S. Sedra and K.S. Smith, “Microelectronic circuits”, 5th ed., New York: Oxford University Press, 2004, 1283 p.