SINGLE POWER SUPPLY OPERATION
EXPERIMENT IX

SINGLE POWER SUPPLY OPERATION

Most op-amps are desired to operate from power supplies; but if we limit our applications to the amplification of AC signals, we may operate with a single supply. When the op-amp is operated in this manner, the quiescent output voltage (the output with zero input) is usually biased at one half of the supply voltage and coupling capacitors are used on the input and output to block the DC bias component. In effect, we are making the op-amp think that ground is the usual negative supply voltage is the usual DC ground reference. We are still operating the op-amp between two supply voltages. All we have done is charged the absolute values of these voltages.

Figure 1 shows a voltage follower operated in this manner Resistors R1 and R2 form a voltage divider that puts the noninverting input of the op-am at a DC value of 6V.

![Figure 1: Single-Supply Voltage Follower](image)

R1, the 100K resistor, as almost no DC voltage drop across it, since a very small DC bias current is the only DC current following through it. Capacitor C2 is a by-pass to insure that the lower end of R1 is at AC ground potential. Since the DC input to the op-amp is 6V, the DC output will also be 6 V DC level.

The circuit has gain of plus one, and the output is duplicated of the input. The AC signal source sees the 100K resistor in parallel with the very high input impedance of the follower as its load. For all practical purposes, the AC input impedance to this stage is about 100K. The 100K resistor is not absolutely necessary, but the AC input impedance in this case for the circuit shown would be only about 5K.

If a DC component is not desired in the output signal, a coupling capacitor may be used between the op-amp output and the load to block the DC.

The AC voltage gain of this circuit is one, and the DC voltage gain is zero. We have a follower circuit that works only for AC signals, and requires only a single power supply. The reactance of the circuit coupling capacitor should be small compared to R1 at the frequency to be amplified. Input and output coupling capacitors serve the same purpose as they do in the single transistor amplifier.

**Calculations:** Find $V_A(t)$, $V_B(t)$, $V_C(t)$, $V_D(t)$ voltages in Fig2.
EXPERIMENTAL WORK

The purpose of this experiment is to demonstrate the theory of operating of an AC-coupled voltage follower using a single power supply.

Materials Required:

1. Power supply, frequency generator and board
2. Dual channel oscilloscope
3. 741 CP op-amp
4. 100K, 10K and 2.2K
5. 1×0.1µF and 2×10µF capacitors
6. Volt-ohm meter (must be high impedance)

Basic Relationships: AC gain=1 and DC output voltage is one-half of the supply voltage.

Procedure:

1) Build the circuit of Fig.2 The signal source is taken directly from the sine-wave output of the function generator,

\[ V_{in}(t) = 2\sin 2000\pi t \text{ volts.} \]

\[ V_E = +12\text{Vdc.} \]

Opamp supply voltage: +Vcc=12 Vdc, -Vcc=0V (not -12Vdc!)

![Figure 2](image)

2) Apply power and measure the DC voltage at the noninverting input of the op-amp, at the output of the op-amp and at the top of C2 with a high impedance meter. These readings should be the same if the effect of meter loading is not significant.

3) Measure the DC voltage across the load resistor.
• Using the oscilloscope, measure the AC input and output signals and calculate the AC gain.

• By using the scope, measure the DC and AC voltages at the nodes A, B, C, D and by combining these values write down the voltage expressions for each node:

\[ V_A(t) = \ldots \]
\[ V_B(t) = \ldots \]
\[ V_C(t) = \ldots \]
\[ V_D(t) = \ldots \]
INSTRUMENTATION AMPLIFIERS

An instrumentation amplifier is one of the key elements in modern analog data systems. It is a very precise amplifier that exhibits high linearity, low offset, minimal drift and a low change of gain with temperature variations. Modern instrumentation amplifiers are available in a single package, but we may demonstrate the internal functions with three conventional op amps and seven resistors.

![Instrumentation Amplifier Diagram]

**Figure 3 Instrumentation Amplifier**

Op-amp A3 with the three R resistors and one R can be forms a differential amplifier with a gain of one. Resistor R can be made variable to balance out any common voltage. Op-amps A1 and A2 buffer the inputs and provide gain. A single resistor, aR programs the gain. The terminal connected to E2 behaves as an inverting input. The terminal connected to E1 behaves as a noninverting input. The differential gain of the amplifier is given by:

\[ Av = \frac{V_o}{(E_1-E_2)} = 1 + \frac{2}{a} \]
EXPERIMENTAL WORKS

The purpose of this experiment is to demonstrate the theory of operation of an instrumentation amplifier by simulating its internal function with low-cost op-amps.

Materials Required:

1. Function generator and board,
2. 741 CP op-amp,
3. 2xTL-0R1 op-amps,
4. Dual channel oscilloscope
5. 6x10K resistors
6. 100K resistor and 10K potentiometer

Basic Relationships:

\[ Av = 1 + \frac{2}{a} = \frac{V_o}{(E_1-E_2)} \]

Procedure:

1) Build the circuit of Figure 4. Be careful not to forget the power supply connections to all three op-amps. The 100K and the 10K potentiometers form the two sides of a bridge circuit. Resistor aR controls the differential gain and will be specified as needed. Initially aR is left out. The signal is taken from the sine-wave output of the function generator.

2) Set the oscilloscope conirol as follows:
   a) Channel 1 at 1V/div
   b) Channel 2 at 1 V/div
   c) AC coupling
   d) Time base at 500 usec/div
   Set wiper arm of the 10 K and 100 K pots at mid range.

3) Apply power to the circuit and adjust The 100 K pot to supply a sine-wave one-half volt larger than that supplied by the 10K pot. This makes the differential input
signal equal to $\frac{1}{2} V$.

\[ E_2 - E_1 = 0.5 \text{ V} \]

4)

a) Measure and record the output voltage.
b) Connect an $aR=10\text{K}$ and measure and record the output voltage.
c) Connect an $aK=5\text{K}$ (two $100\text{K}$'s in parallel) and measure and record the output voltage.
d) Calculate the expected gains from $\frac{Vo}{(E_1-E_2)}$ and compare with the measured values. Vary the oscilloscope settings as required.

<table>
<thead>
<tr>
<th>$aR$</th>
<th>$1+2/a$</th>
<th>$\frac{Vo}{(E_1-E_2)}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10K</td>
<td></td>
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<tr>
<td>5K</td>
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