Differential Pair

Goal:

To construct a basic differential pair and to find its

a) Common Mode gain,
b) Differential gain,
c) Common Mode Rejection Ratio and
d) Slew Rate.

Set up:

Simple Differential Pair

Bias details:

1) Connect the A and B terminals to the ground.
2) Now adjust the Rb (10k) pot so that x and y are approximately near 0V.
3) Make sure x = 0V rather than y = 0V, as we are to tap the output at x.
4) Now disconnect A and B from the ground.
**OUTPUT OFFSET VOLTAGE**

1) To find the output offset voltage, connect both A and B to ground.

2) Measure the output voltage between x and y. This is the output-offset voltage.

**COMMON MODE GAIN**

**Procedure:**

1) Here the main idea is we are finding the gain of the opamp by giving a common signal to both the inputs.

2) First fix the DC point of X and Y to 0V, by adjusting Rb (if necessary).

3) Give the same input signal [sine-100mVpp-1kHz-zero DC offset] both to A and B terminals.
4) Now adjust the DC offset of the signal generator, till you see a full sine wave with maximum swing on the node X.

5) Using the oscilloscope, trace \( V_{in} \) and \( V_{out} \). [\( V_{out} = V_{xy} \)]

6) Now **Common mode gain** = \( V_{out} / V_{in} \). [Take the peak to peak values]

7) How does the waveform at \( z \) look like? Why?

Here is how the waveforms at various point look like,

- **At \( V_{in} \):** \( V_{av} = 0 \, \text{V}, \, V_{pp} = 100 \, \text{mV} \)
- **At \( Y \):** \( V_{av} = 2.5 \, \text{V}, \, V_{pp} = 100 \, \text{mV} \)
- **At \( X \):** \( V_{av} = 1.9 \, \text{V}, \, V_{pp} = 100 \, \text{mV} \)
- **At \( Z \):** \( V_{av} = -0.15 \, \text{V}, \, V_{pp} = 75 \, \text{mV} \)

- **Between \( X \) and \( Y \):** \( V_{pp} = 0.02 \, \text{mV} \)

Actually it should almost be a straight line, but you may notice slight oscillations, due to the slight difference in the gains of the transistors.
**DIFFERENTIAL MODE GAIN**

**PROCEDURE:**

1) Here the idea is to find the gain of the opamp by wiggling the inputs in the opposite directions i.e. we give a highly differential input. So, don’t use the 10K between the x and y.

2) First fix the DC point of X and Y by adjusting Rb (if necessary). i.e. bring Vx = 0V and Vy = 0V. Make sure Vx = 0 rather than Vy = 0, because Vx is the point where we tap the output.

3) Give the input signal [sine-100mVpp-1kHz-zero DC offset] to the B terminal, as shown in the figure.

4) Adjust the DC offset of the signal generator till you see a full sine wave with maximum swing on the node X.

5) Using the oscilloscope, trace V\textsubscript{in} and V\textsubscript{out}. [ Here Vout = Vx and not Vxy! ]

6) Now **Differential mode gain** = \( \frac{V_{out}}{V_{in}} \). [Take the peak to peak values]

How does the waveform at z look like? Why?
Here is how the waveforms at various points look like,

**COMMON MODE REJECTION RATIO**

The Common mode rejection ratio is

\[ \text{CMMR} = \frac{\text{Differential mode gain}}{\text{Common mode gain}} \]

Next we shall move, to find the Slew rate of the amplifier we designed.
**PROCEDURE:**

In the previous set up which we used for finding the Differential mode gain, just switch the input waveform from a sine wave to a square wave [5Vpp − 10KHz, + 2.5V DC offset] (you can do this from the function generator itself). The reason why we use a square wave is that only a square wave has a rapid change from 0 to 5V, in the shortest time.

The waveforms at various points would look like,

**Vin**

Vin

Vpp = 5V, Vav = 2.5V

**Vx**

Vx

Vpp = 4.3V, Vav = 1.2V
You need to consider the 10% to 90% rise time to find the slew rate. Because this is the portion which will tell how fast the opamp responds to the rapid change in input voltage.

Now \textbf{slew rate} in Hz = 1/(Time taken for 10 to 90\% rise)

\textbf{RESULTS:}
For the simple differential pair with a Tail Resistor,

a) Common Mode gain is ___.

b) Differential gain is ___.

c) Common Mode Rejection Ratio is ___.

d) Slew Rate is ___.