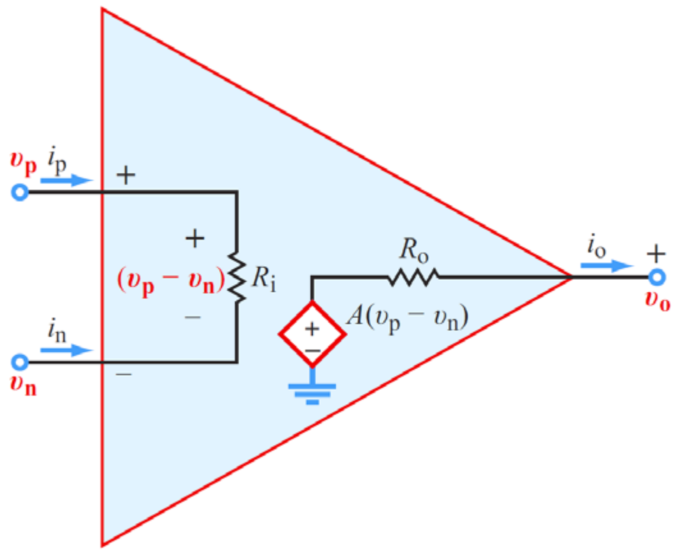
Open loop amplifier model and parameters

The operational amplifiers used in this class can be modeled for many practical applications, with a linear circuit. That is to say, we can use linear elements we've already learned about to build a simple model of how an amplifier would respond to changes in currents and voltages.



- In the model above, v_p and v_n are referred to as the non-inverting and inverting terminals, respectively. R_i and R_o are the input and output resistances, respectively.
- In an ideal amplifier, R_i is infinite (that is, the input is an open circuit); $R_0 = 0\ \Omega$ (that is, the voltage source is shorted directly to v_o) and A is infinite (more on this soon).
- In typical op-amps, $R_i > 10^8\ \Omega$, $R_o < 10\ \Omega$, $A > 10^6$ V/V.
- The *power rails* (the two terminals through which op amps receive power from an external supply) are not shown in the model above. Sometimes they are drawn into the figure.
- The positive rail (historically labelled V_{DD} or V_{CC}) sets the highest voltage the amplifier can output (under any condition).
- The negative rail (historically labelled V_{SS} or V_{EE}) sets the lowest voltage the amplifier can output (under any condition).

The Comparator

Notice that if A is very high, the open loop amplifier above will likely be *railed*. That is, its output will be either V_{DD} or V_{SS}. Why? Consider an amplifier with an A of 10^6 V/V, V_{DD} = 10 V and V_{SS} = -10 V. For simplicity, assume R_i is infinite and R_0 is 0 Ω. For any input where $v_p – v_n > 10$ µV, the output will be 10 V. Conversely, for any input where $v_p – v_n < -10$ µV, the output will be -10 V. This means for any reasonable input voltage difference, the output will either be 10 V or -10 V (there is a very narrow range, between -10 µV and 10 µV, where the output is exactly $A*(v_p-v_n)$ but it is negligible; the larger this A, the smaller this linear range is). In this mode, the amplifier acts as a comparator; that is, it compares the inputs: if v_p is larger than v_n, it outputs V_{DD}; if vn is larger than vp, it outputs V_{SS}.

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