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APPLICATION NOTE 4107

Operational Amplifiers Glossary of Key Terms

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Abstract: This application note is a collection of operational amplifier (op amp) terms and their specifications. The article provides a handy reference guide for designers.

This glossary defines the operational amplifier (op amp) specifications that are commonly found in the Electrical Characteristics Table of the typical op-amp data sheet.

1. **Common-Mode Input Resistance** (R_{INCM})
   For op amps operating in the linear region, this term defines the input common-mode voltage range divided by the change in input bias current across that range.

   $$R_{INCM} = \frac{\Delta V_{CM}}{\Delta I_B}$$

2. **DC Common-Mode Rejection** (CMR_{DC})
   This is a measure of the op amp's ability to reject DC signals present in equal measure at both inputs. CMR_{DC} can be calculated using the common-mode voltage range (CMVR) and the change in peak-to-peak input offset voltage across that range.

   $$CMR_{DC} = 20 * \log\left(\frac{\Delta V_{CM}}{\Delta V_{OS}}\right)$$

3. **AC Common-Mode Rejection** (CMR_{AC})
   CMR_{AC} is a measure of the amplifier's ability to reject AC signals present in equal measure at both inputs. It is a function of differential open-loop gain divided by common-mode open-loop gain. CMR_{AC} is usually specified at a given frequency and over a DC common-mode range.

   $$CMR_{AC} = 20 * \log\left(\frac{A_{OL(DIFF)}}{A_{OL(CM)}}\right)$$

   where $A_{OL(DIFF)} = \frac{\Delta V_{OL}}{\Delta V_{OS}}$ and $A_{OL(CM)} = \frac{\Delta V_{OUT}}{\Delta V_{CM}}$

4. **Gain-Bandwidth Product** (GBW)
   This is the constant product $A_{OL} * f$ in the region of the -20dB/decade rolloff on the open-loop Gain

vs. Frequency characteristic curve.

5. **Input Bias Current** (I_B)
   For op amps operating in the linear region, this term indicates the current that flows into the inputs, averaged.

6. **Input Bias-Current Drift** (TC_{IB})
   This is the change in input bias current due to the change in temperature. TC_{IB} is usually expressed in pA/°C.

7. **Input Offset Current** (I_{OS})
   This is the difference between the currents flowing into the two inputs.

8. **Input Offset-Current Drift** (TC_{IOS})
   This is the change in input offset current due to the change in temperature. TC_{IOS} is usually expressed in pA/°C.

9. **Differential-Mode Input Resistance** (R_{IN})
   This is the change in input offset voltage divided by the change in input current. This change results from that changing voltage. For either input with the other input connected to a fixed common-mode voltage:

   $$R_{IN(DIFF)} = \frac{\Delta V_{OS}}{\Delta I_{IN}}$$

10. **Output Impedance** (Z_O)
    For op amps operating in the linear region, this term indicates the small-signal internal impedance of the output terminal.

11. **Output Voltage Swing** (V_O)
    This term indicates the maximum peak-to-peak voltage swing that the output can achieve without clipping the signal. V_O is usually specified into a given load resistance and relative to the supply rails.

12. **Power Dissipation** (P_d)
    This is the quiescent power dissipated by the device under the given supply voltages. P_d is usually specified with no load attached to the output.

13. **Power-Supply Rejection Ratio** (PSRR)
    This measures the ability of an amplifier to maintain its output voltage unchanged as the supply voltage varies. PSRR is often determined by measuring the change in input offset voltage as a result of the change in power-supply voltage.

    $$PSRR_{dB} = 20 * \log \frac{\Delta V_{OS}}{\Delta V_{SUPPLY}}$$

14. **Slew Rate** (SR)
    This is the maximum large-signal rate of change of the output voltage divided by the amount of time that the change takes to occur. SR is usually expressed in V/µs, and sometimes listed separately for positive-moving and negative-moving signals.

15. **Supply Current** (I_{CC}, I_{DD})
    This indicates the quiescent current required by the device at the given supply voltage. These terms are usually specified with no load attached to the output.

16. **Unity Gain Bandwidth** (BW)
    This is the maximum frequency for which the open-loop gain is greater than one.

17. **Input Offset Voltage** (V_{OS})
    This indicates the voltage difference that, when applied differentially to the inputs, causes the output to equal zero.

18. **Input Offset-Voltage Drift** (TC_{VOS})
    This indicates the change in input offset voltage over temperature, usually expressed in µV/°C.

19. **Input Capacitance** (C_{IN})
    For op amps operating in the linear region, C_{IN} is the capacitance of either input terminal with the other input terminal connected directly to ground.

20. **Input Voltage Range** (V_{IN})
    This is the voltage range at the inputs over which the amplifier operates with predictable results. V_{IN} is usually expressed relative to the supply rails.

21. **Input-Voltage Noise Density** (e_N)
    For op amps, input voltage noise can be modeled as a series noise-voltage source connected to either input. e_N is usually expressed in $nV/\sqrt{Hz}$ (nanovolts per root Hertz) and usually specified at a single frequency.

22. **Input-Current Noise Density** (i_N)
    For op-amps, input current noise can be modeled as two noise current sources, one connected from each input to a common point. i_N is usually expressed in $pA/\sqrt{Hz}$ (picoamps per root Hertz) and usually specified at a single frequency.

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