Operational Amplifier Inputs

When does input bias current become a concern? Which architecture offers the lowest offset voltage? This application note serves as an introduction to common op amp input structures and their associated design advantages and challenges.

Operational amplifier (op amp) inputs vary widely in structure and performance. This document serves as an introduction to common op amp input structures and how to identify what type is used for a particular part number by examination of the Electrical Characteristics table.

Each different structure type offers its own advantages and disadvantages; therefore, Maxim will continue to introduce op amps with a variety of configurations to optimize each product for its intended application. The table below lists the various types we have used; some are very common, whereas others are represented with only one or two examples in our portfolio.

Op Amp Input: Types and Parameters

Type	V_{OS}	I_B	I_{OS}	TC_{IB}	Comments
Bipolar PNP	100µV to 2mV	100nA to 1µA	10%I_B	< 20%	Most common due to its V_{CM}, which includes the negative supply rail.
Bipolar NPN	10µV to 1mV	100nA to 1µA	10%I_B	< 20%	Usually used for dual-supply precision amplifiers.
Bipolar Rail to Rail	500µV to 5mV	±100nA to 1µA	50%I_B	< 40%	Uses both NPN and PNP types. Most common rail-to-rail input stage. I_B changes polarity with different V_{CM}s.

CMOS P-Channel	1mV to 20mV	±10pA to 1nA	= I_B	10x per 30° C	Lowest I_B, most common CMOS type due to its V_{CM}, which includes the negative supply rail.
CMOS N-Channel	1mV to 20mV	±10pA to 1nA	= I_B	10x per 30° C	Not very common, similar in performance to p-channel without single-supply operation.
CMOS Rail to Rail	1mV to 20mV	±10pA to 1nA	= I_B	10x per 30° C	Uses both n- and p-channel devices. Lower I_B, but higher V_{OS}, compared to bipolar rail to rail.
Other Varieties					
Bipolar NPN with I_B Cancellation	10µV to 200µV	±10nA to 100nA	50%I_B	< 40%	This is used on the MAX400, MAX427, MAX437, OP07, and MXL1028. An internal current mirror is used to cancel the input bias current.
Bipolar Current-Mode Feedback	500µV to 5mV	±100nA to 10µA (IN+ only)	NA	< 40%	IN+ is high impedance, IN- is low impedance. Maxim has only a few CMFB types, generally high speed. Limited range of useable feedback impedance.
JFET Op Amp	500µV to 2mV	±10pA to 1nA	= I_B	10x per 50° C	

The bipolar PNP is our most common input because of its inherently low offset and single-supply operation. The bipolar rail-to-rail stage is challenging its dominance, constituting more than 50% of our new op amp products. The remaining input stages account for less than 20% of our op amp library.

Generally if customers are looking for low offset voltage, they will have to use one of the bipolar input stages. Should they want high impedance, they will require a CMOS input stage. If they

ask for a JFET input stage, chances are a CMOS type might satisfy their criteria. Our current offering in JFET input stages is essentially nonexistent and very high priced.

Most of Maxim's op amps can be identified using the above table as a guideline. Compare the offset voltage, the bias current, and the offset current to determine which of the above categories is the closest match.

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