Analog Devices Provides Amplifiers for Every Application

Why are there so many different types of operational amplifiers (op amps)? Here at Analog Devices our engineers continue the pursuit of the illusive ideal op amp. And while we're extremely close to its realization, unfortunately it still exists only in textbooks. That is why we are committed to offering such a broad portfolio of op amps to meet the many and varied needs of our customers.

Selecting an op amp is no trivial task: with so many different types of amplifiers, categories, architectures, and parameters to choose from, the process can be difficult. Each customer and application requires slightly different performance. It doesn't matter whether you're designing a coffee maker (yes, op amps can be found in coffee makers) or the next generation medical imaging system, Analog Devices has the right amplifier to meet your needs.

This document will help you quickly and easily identify the right op amp(s) for your application. Inside you'll find a list of op amp terminology and processes used to fabricate the ICs, a variety of selection tables, application guides, design tools, and a handy detachable op amp reference wall chart. We hope you'll refer to this selection guide often and that it provides you with a better understanding and appreciation of op amps and their many applications.

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Op Amp Glossary

Common-Mode Voltage Range (CMVR)

Also known as input voltage range, CMVR is the allowable input voltage range at both inputs before clipping or excessive nonlinearity is seen at the output.

Common-Mode Rejection Ratio (CMRR)

The ratio of the common-mode voltage range (CMVR) to the change in the input offset voltage (ΔVo_{OS}) over this range. The result is expressed in dB. CMRR (dB) = 20log (CMVR/ΔV_{OS})

Full Power Bandwidth

The maximum frequency measured at unity gain for which the rated output voltage can be obtained for a sinusoidal signal at rated load without distortion due to slew rate limiting.

Gain Bandwidth Product (GBW)

The product of open-loop gain and bandwidth at a specific frequency.

Input Bias Current (I_B)

The current at the input terminals.

Input Bias Current Drift

The proportional change in input bias current vs. temperature over a specified range of temperature.

Input Offset Current

The difference between the two input currents.

Input Offset Current Drift

The ratio of input offset current change over a specified temperature range, with the output held a constant voltage.

Input Offset Voltage Drift (T_CV_{OS})

The ratio of change in input offset voltage to a change in temperature.

Offset Voltage (V_{OS})

The differential voltage needed across the op amp input terminals to obtain zero output voltage. Offset voltage values range varies by process and design technology:

- Auto-Zero Op Amps: $<$1 µV
- Precision Op Amps: 50 µV to 500 µV
- Best Bipolar Op Amps: 10 µV to 25 µV
- Best JFET Iput Op Amps: 100 µV to 1000 µV
- Best Bipolar High Speed Op Amps: 100 µV to 2000 µV
- Untrimmed CMOS Op Amps: $>$2 mV
- DigiTrim® CMOS Op Amps: $<$100 µV to 1000 µV

Open- Loop Gain (A_{VO})

The ratio of the output voltage to the input offset voltage between the two input pins. The result is expressed in dB. Gain is usually specified only at dc (A_0), but for many applications, such as high speed amplifiers for video and RF, the frequency dependence of gain is also important. For this reason the open loop gain and phase response is published for each amplifier.

Operating Supply Voltage Range

The supply voltage range that can be applied to an amplifier for which it operates within specifications. Many applications implement op amp circuits with balanced dual supplies, while other applications for energy conservation or other reasons, use single-supply. For example, battery power in automotive and marine equipment provides only a single polarity. Even line-powered equipment, such as computers, may have only a single-polarity built-in supply, furnishing +5 V or +12 V dc for the system, or often as low as 1.8 V, with newer applications going even lower.

Power Supply Rejection Ratio (PSRR)

The ratio of the change in power supply voltage to the change in input offset voltage. The result is expressed in dB. PSRR = 20log ($\Delta V_{SY}/\Delta V_{OS}$)

Settling Time

The amount of time required for an amplifier to settle to some predetermined level of accuracy or percentage of output voltage after the application of a step input.

Slew Rate

The maximum rate of change of output voltage under large signal condition. The result is usually expressed in V/µs.

Supply Current

The current required from the supply voltage to operate the amplifier with no load.

Small Signal Unity Gain Frequency

The frequency at which the open-loop gain is unity or 0 dB. This applies only to signals under 200 mV. Due to slew rate limiting, it is not possible to obtain large output voltage swings at high frequencies.

Clamp Amplifiers

Clamp amplifiers allow the designer to specify a high (VCH) and low (VCL) output clamp voltage so the output signal will clamp at the specified levels. Analog Devices' unique CLAMPIN™ input clamp architecture offers significant improvement in clamp performance compared to traditional output clamping devices, minimizing clamp error and distortion in the clamp region.

Common-Mode Linearized Amplifiers

Increasing the linear input range of the input stage optimizes operational amplifier large signal distortion. This can be accomplished through the use of architectures such as degenerated differential structures and class AB input stages, both of which increase noise and lower precision. An alternate method is to linearize using a common-mode structure whose noise is rejected by the inherent differential nature of the input stage while also maintaining such precision metrics as CMRR, PSRR, and V_{OS}. Analog Devices has numerous new amplifiers that now feature this new technology and has patented the common-mode linearized input architecture.

Current Feedback Amplifiers

Current feedback amplifiers are primarily used in applications that require very high speed operation, large slew rates, and low distortion. The fundamental concept is based on the fact that, in bipolar transistor circuits, currents can be switched faster than voltages, all other things being equal. Unlike voltage feedback amplifiers (VFB), CFB amplifiers do not have balanced inputs. Instead, the noninverting input is high impedance, and the inverting input is low impedance. The open-loop gain of the CFB is measured in units of Ω (transimpedance gain) rather than V/V as for VFB amplifiers. Also, the value of the feedback resistor plays a direct role in the CFB's stability. Therefore, adhering to the recommended feedback resistor suggested in the data sheet is highly recommended.

Differential Amplifiers

Differential amplifiers allow the process of single-ended input to complementary differential outputs or differential inputs to differential outputs. These amplifiers feature two separate feedback loops to control the differential and common-mode output voltages. Analog Devices' differential amplifiers are configured with a V_{OCM} pin, which can be easily adjusted for setting output common-mode voltage. This provides a convenient solution when interfacing with analog-to-digital converters (ADCs). ADI also offers a series of differential receiver products that convert differential input signals to single-ended output.

Quad Core (H Bridge)

Analog Devices has patented the quad core architecture, which supplies *current on-demand* to charge and discharge the internal dominant pole capacitor, while allowing the quiescent current to be small. This patented architecture enables amplifiers to provide high slew rates with low distortion at low supply currents.

Overvoltage Protection (OVP) Amplifiers

An OVP amplifier is the most robust solution to protect the amplifier and entire circuitry from outside the rail input voltages due to manufacturing shorts, power supply timing, or human error. OVP is able to protect real estate from various unexpected errors, which in turns save time and money. OVP amplifiers require no external circuitry to provide protection.

Zero-Drift Amplifiers

Zero-drift amplifiers dynamically correct the offset voltage to achieve nanovolt-level offsets and extremely low offset drifts due to time and temperature. The 1/f noise, seen as a dc error, is also removed. Zero-drift amplifiers provide many benefits to designers, as temperature drift and 1/f noise, always nuisances in the system, are otherwise very difficult to eliminate. In addition, zero-drift amplifiers have higher open-loop gain, power supply rejection, and common-mode rejection as compared to standard amplifiers; and their overall output error is less than that obtained by a standard precision amplifier in the same configuration.

Zero Input Crossover Distortion (ZCO) Amplifiers

Traditional rail-to-rail input amplifiers have an input stage that comprises two differential pairs, a p-type and an n-type. During the transition of the input common-mode voltage from the lower to the higher supply voltage, one of the differential pairs turns off and the other turns on. This transition causes crossover distortion. Zero input crossover distortion (ZCO) amplifiers solve this problem by integrating an on-chip charge pump. The charge pump increases the internal supply voltage, thus providing more headroom to the input stage. This allows the input stage to handle a wider range of input voltages (rail to rail) without using a second differential pair. As a result, crossover distortion is avoided.

Amplifier Process and Trimming Technology

Process Technology

Bipolar

Bipolar technology delivers the best overall performance amplifiers. It offers high output current drive, high voltage operation, and low noise.

Extremely Fast Complementary Bipolar (XFCB 1.5)

Analog Device's XFCB 1.5 technology is a suite of advanced bipolar fabrication processes that features dielectric isolation, high speed complementary NPNs and PNPs with 3 GHz to 8 GHz frequency transition, precision capacitors, and low temperature-coefficient thin film resistors that can be trimmed at the wafer level. Dielectric isolation allows much tighter spacing between components and removes the possibility of latch-up. Nonlinear device-to-substrate capacitance that limits device speed and distortion performance is eliminated. XFCB1.5 has supply voltage options from 8 V to 26 V; this allows the selection of the fastest devices possible for the required input and output voltage ranges.

XFCB3

Analog Devices' XFCB3 technology features full dielectric isolation, silicon-germanium hetero-junction NPNs with frequency transition up to 50 GHz and double-poly PNPs with frequency transition up to 18 GHz, precision capacitors, and low temperature coefficient thin film resistors. Minimum feature size is a factor of three less than XFCB1.5. This process family has enabled a new generation of high speed, ultralow distortion differential amplifiers and op amps.

36 V *i*Polar

Analog Devices' *i*Polar™ 36 V precision bipolar process is highly optimized for linear circuits, yielding new levels of performance, size, and value. The *i*Polar process combines the advantages of precision bipolar and JFET with lateral dielectric isolation and modular processing. The transistors on *i*Polar devices have been redesigned from the ground up and are optimized for speed, noise, matching, linearity, and stability at lower power levels. This enables greater signal chain integration without compromising performance.

16 V *i*CMOS Amplifiers

Analog Devices' *i*CMOS® industrial manufacturing process technology combines submicron CMOS with high voltage complementary bipolar technologies. It enables the development of a wide range of high performance analog ICs capable of 30 V operation in a smaller footprint. Unlike analog ICs using conventional CMOS processes, *i*CMOS components can tolerate high supply voltages, while providing increased performance, dramatically lower power consumption, and reduced package size. *i*CMOS components tolerate high voltages (greater than 6 V regular CMOS amps) while employing digital design techniques such as auto-zero and DigiTrim technologies.

JFET Input Amplifiers

JFET input amplifiers have the advantage over bipolar devices by having an extremely high input impedance along with low noise performance, making them very useful in amplifier circuits using very small signals such as high source impedance sensors and photodiodes. A typical JFET has a voltage noise slightly larger than a BJT, but its current noise is significantly lower.

Trimming Technology

Laser Trim

When extremely fine adjustment is required, laser trimming is most effective. By controlling the path and speed of the laser beam, the resistor's value can be adjusted to very precise values. Analog Devices pioneered the use of thin film resistors and laser trimming and uses this technology extensively in precision amplifiers, references, and converters.

Zener Zapping

With each zap removing a predefined resistance value, the nature of the trims is discrete. It is most cost-effective for fairly large geometry processes. Analog Devices pioneered the use of Zener-zap trimming and created the industry standard OP07 precision amplifier.

DigiTrim

Analog Devices' DigiTrim™ is a patented in-package trimming process that delivers guaranteed high accuracy. This in-package process technology eliminates the need for laser trimming during manufacturing and minimizes the input offset of operational amplifiers.