STMicroelectronics Operational Amplifiers (Op Amps) Instruction Manual

**Operational Amplifiers
(Op Amps)
Quick reference guide**

Instruction Manual
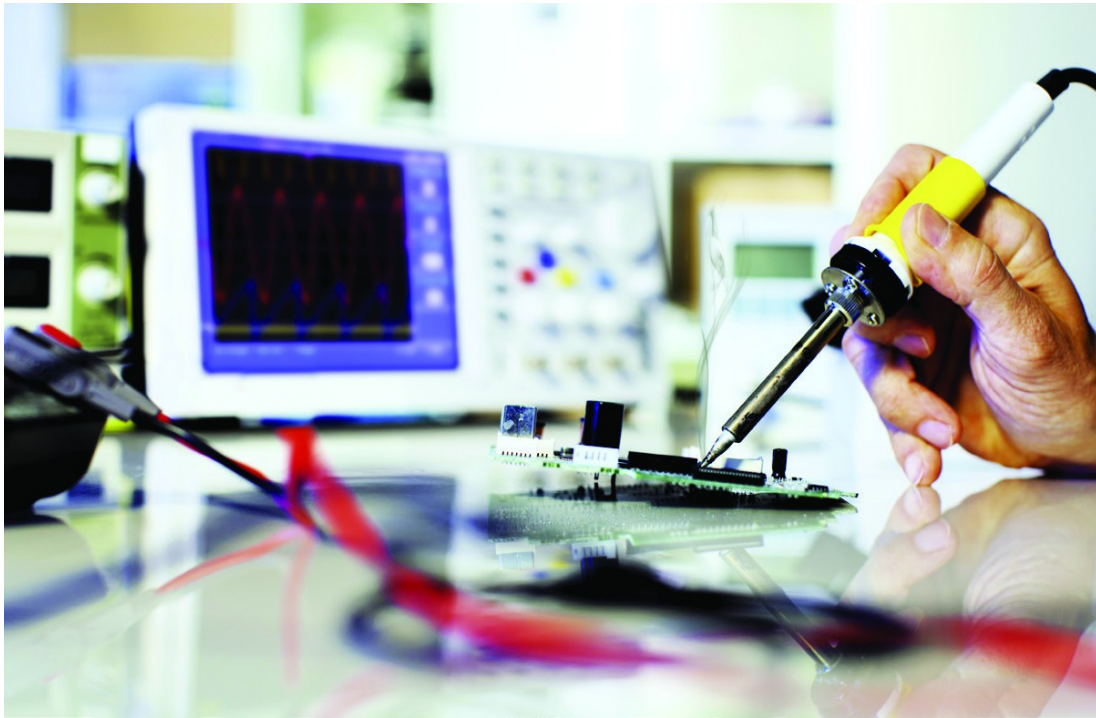
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Operational Amplifiers (Op Amps)

In today's digital world, many signals start as an analog one. Many sensors already have their own analog signal conditioning circuit, but an operational amplifier is still a key device when you need more complex amplification and filtering, or just for interfacing analog signals with an ADC or a microcontroller. This reference guide provides you information about ST's most recent operational amplifiers and their characteristics.

HOW DO I PICK THE RIGHT OP AMP FOR AN APPLICATION ?

Even though some may consider op amps as a commodity, they are not. Modern high-performance devices have a wide range of variable parameters. One device can have almost ideal parameters, while another may be little worse and others can be completely different. The main key performance indicators for operational amplifiers can be listed as following:

Supply voltage (V)	Quiescent current (µA)	Input offset voltage (mV)	Input bias current (pA)
Gain bandwidth product (MHz)	Slew rate (V/µs)	Rail-to-rail input and output	Noise level (nV/√Hz)

TYPICAL OP AMP APPLICATIONS AND KEY PARAMETERS

Each application has different key requirements for operational amplifier performance. Generally, we can divide applications into several different categories.

Amplification of low voltage signals
When amplifying low-voltage signals, you definitely need high precision op amps since the input offset voltage directly affects your measurement. On the other hand, most low-voltage signals come from low-impedance sources; therefore, the input bias current is not critical. A differential amplifier or an instrumentation amplifier is a typical circuit. Current sensing is a typical application where you usually need low- or high-rail features and possibly an appropriate bandwidth with a slew rate to track PWM. Other applications include Wheatstone bridges circuits e.g. strain gauges, RTD sensors or resistive sensors. In such applications, rail-to-rail inputs are not needed in most cases, but you may require a low-noise device. The same can be applied to thermocouples.

Small current amplification
Sensors providing a small current will require an op amp with a low input bias current. All of these applications use

a transimpedance amplifier where the input offset voltage is not usually critical.

A typical application is a photodiode current sensing circuit used in communications, light curtains, smoke detectors, electrochemical gas sensors or optical heart rate monitors. In this case, the device is quite often powered from a battery so power consumption can be important or the device needs to be fast and a high slew rate may be required.

ADC buffering

Interfacing an analog signal with an ADC can be tricky since the ADC requires a high current within a short time to charge input capacitors. Often an additional capacitor is used at the op amp output which may cause stability issues and may require the use of compensation techniques. In any case, errors caused by an op amp should be less than one LSB of the ADC.

Additionally, an op amp can be used as a basic anti-aliasing filter.

Other signal conditioning

More complex signal conditioning circuits have different requirements and designers should keep in mind all the abovementioned parameters and how they each affect functionality and performance.
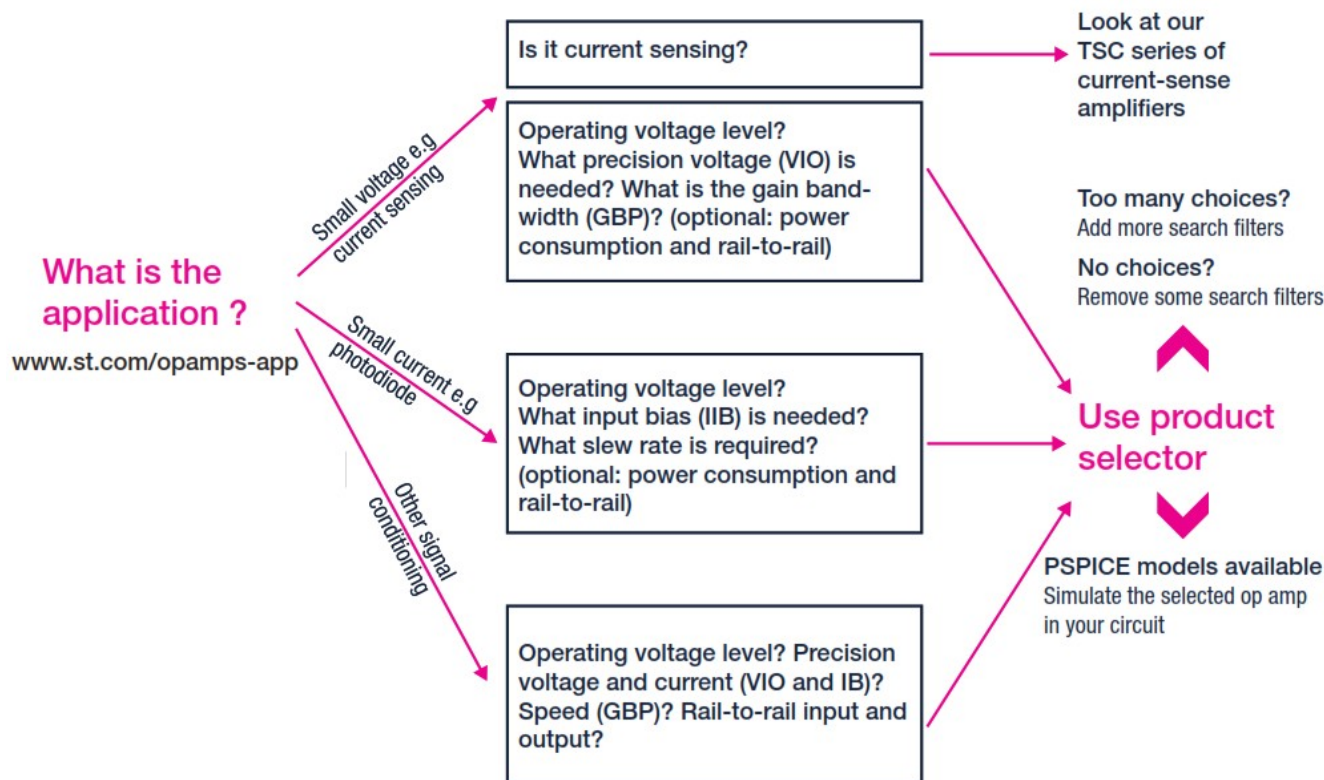
OP AMP LONGEVITY COMMITMENT

Most of ST's newly developed high-performance op amps come with our 10-year longevity commitment.
The list gets longer every year.

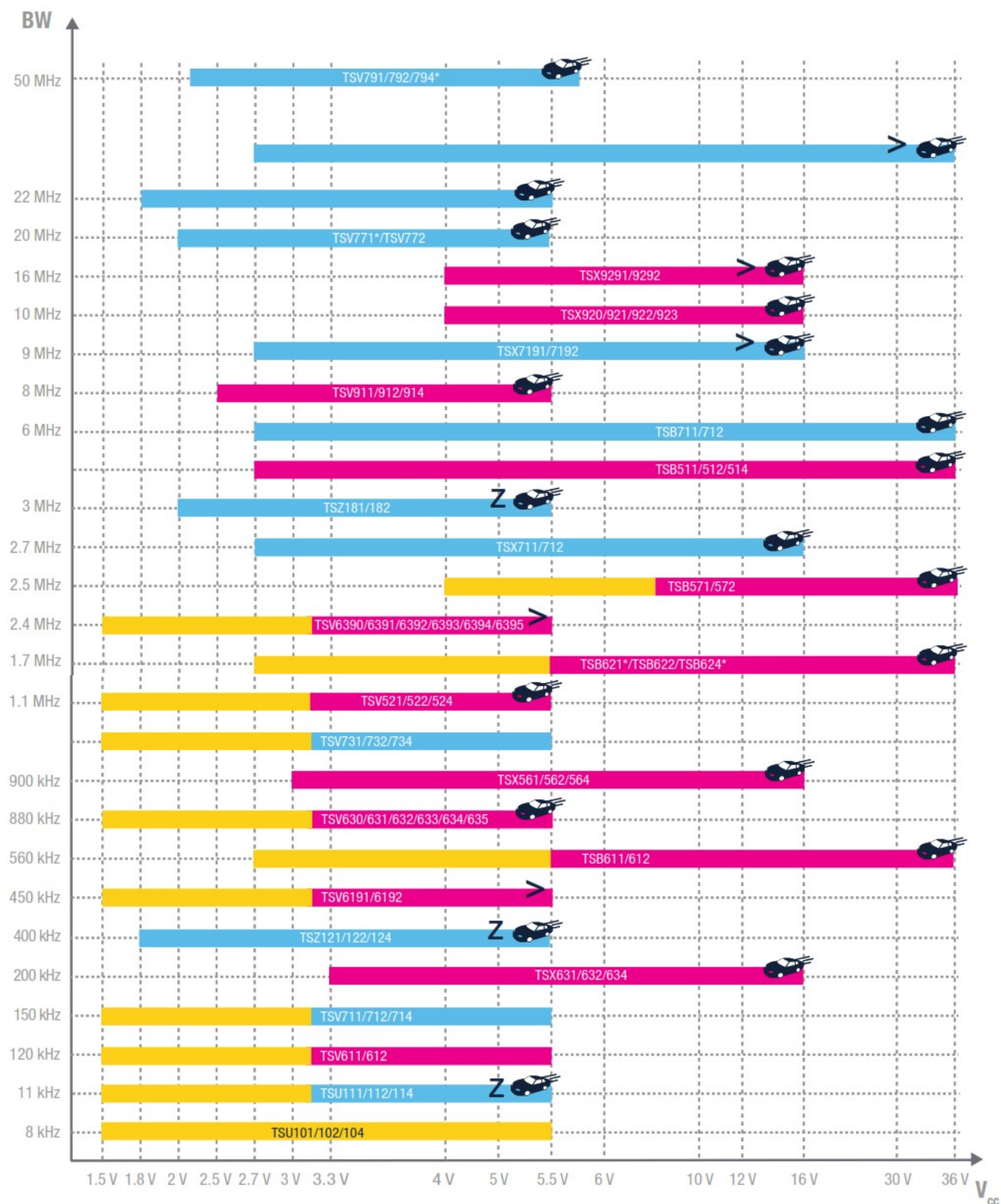

STEP-BY-STEP OP AMP SELECTION USING THE ST OP AMPS APP

https://goo.gl/DKw5D	https://goo.gl/XYYRX	http://www.wandoujia.com/apps/com.colliard.ST_opamps

DON'T GET LOST IN ST'S OP AMP NAMING CONVENTION

TSV 7 7 2 2 A I Y S T

Series root name

TSV	High performance 5V
TSU	Nano power 5V
TSZ	Zero drift 5V
TSX	High performance 16V
TSB	High performance 36V
LM	Standard amplifiers

I_{CC} and Speed

Higher value means higher power consumption and faster

Precision

None	Standard device
A	Enhanced Vio

Grade

None	Standard qualification
Y	Automotive grade

Tape and reel

Series root number

1	Family specific
5	High merit factor
6	Micro power
7	High precision
9	High speed

Compensation

None	Standard device (unity gain stable)
9	Higher GBW (stable for gain >5)
Any	Specific to family

#opamps in package

1	Single
2	Dual
4	Quad

With shutdown	
0	Single
3	Dual
5	Quad

Temperature range

I	Industrial temperature range -40 to 125 °C
H	High temperature range -40 to 150 °C
H1	Very high temperature range -40 to 175 °C

Package

C	SC70
D	SO
L	SOT23
P	TSSOP
Q	DFN/QFN
S	Mini SO

BW

50 MHz	TSV791/792/794*
22 MHz	
20 MHz	TSV771*/TSV772
16 MHz	TSX9291/9292
10 MHz	TSX920/921/922/923
9 MHz	TSX7191/7192
8 MHz	TSV911/912/914
6 MHz	TSB711/712
	TSB511/512/514
3 MHz	TSZ181/182
2.7 MHz	TSX711/712
2.5 MHz	TSB571/572
2.4 MHz	TSV6390/6391/6392/6393/6394/6395
1.7 MHz	TSB621*/TSB622/TSB624*
1.1 MHz	TSV521/522/524
	TSV731/732/734
900 kHz	TSX561/562/564
880 kHz	TSV630/631/632/633/634/635
560 kHz	TSB611/612
450 kHz	TSV6191/6192
400 kHz	TSZ121/122/124
200 kHz	TSX631/632/634
150 kHz	TSV711/712/714
120 kHz	TSV611/612
11 kHz	TSU111/112/114
8 kHz	TSU101/102/104

1.5 V 1.8 V 2 V 2.5 V 2.7 V 3 V 3.3 V   4 V   5 V   5.5 V   6 V   10 V 12 V   16 V   30 V   36 V   V$_{cc}$

Legend: —— High precision   —— General purpose   —— Low power

Z Zero drift   > Uncompensated   Automotive   * Under development

GLOSSARY

Supply voltage (VCC) - Voltage difference between the two power pins where the op amp works correctly. In ST's portfolio, one can find 5V, 16V and 36V products.

Quiescent current / Supply current (ICC) – Supply current needed for each operational amplifier in the package

for its operation.

Input offset voltage (VIO) - Differential input voltage of the + and – pins to get the output at the mid-range of the supply voltage. It originates from the matching of internal transistors.

Input bias current (IIB) - Current flowing through an op amp's inputs. Due to op amp biasing requirements and normal operation leakage, a very small amount of current (pA or nA range, depending on the technology) is flowing through its inputs. This may cause problems when large value resistors or sources with higher output impedances are connected at the op amp inputs. This causes relevant voltage drops at the op amp input and therefore errors.

Gain bandwidth product (GBP or GBW) - Product of an op amp's gain and bandwidth. It is measured at 20 dB gain. Defined for small signals.

Slew rate (SR) - How fast an op amp can change voltage on its output. An op amp's output rate of change is limited to the slew rate value. It causes distortion if the signal to be amplified is too fast.

Rail-to-rail input - An op amp with a high rail input is able to deal with input signals up to Vcc+ while a low rail input is able to deal with signals down to Vcc-. Rail-to-rail input op amps can handle input signals from Vcc- to Vcc+.

Rail-to-rail output - Capability of an op amp to drive its output very close to the power supply rails.

Noise level - Op-amps generate random voltages at the output even when there is no signal applied on its input. Such noise comes from the thermal noise (white noise) or 1/f noise, also called flicker noise. For applications with high gain or bandwidth, a noise level may become considerable.

Capacitive load - Can cause an op amp to become an oscillator. The op amp output resistance in connection with a capacitive load results in an additional pole in the circuit transfer function. From the Bode, then it is clearly visible under which operating conditions the circuit can become unstable.

Zero drift - Chopper op amps designed to "self-correct" their VIO errors and also those happening over temperature and over the time. Thanks to their design, zero-drift op amps have their VIO in the range of microvolts and similarly "nano-volt" per Celsius degree drift. Zero-drift op amps have virtually no 1/f noise and also their "aging" over the time is negligible.

Shut down - Op amp operation switch-off. Usually used to reduce the circuit standby current when an application does not run or amplification is not needed. Usually controlled by a dedicated op amp pin.

EMI hardening - An op amp's input pins are very sensitive and might act as a gate for electromagnetic interference in your design.

Some op amps embed EMI filters to attenuate high-frequency signals for 60 dB or more. Strain gauge A sensor used to measure an object's deformation.

RTD sensor - Resistance temperature detectors. Many RTD sensors are constructed from a fine metal wire which is wrapped around a ceramic/glass carry core.

Thermocouple - Every transition between different kinds of metals causes a tiny thermoelectrical voltage. This effect is used in some temperature sensors.

For more information, visit us on **www.st.com/opamps**

Documents / Resources

	STMicroelectronics Operational Amplifiers (Op Amps) [pdf] Instruction Manual TSV7722, Operational Amplifiers Op Amps, Operational Amplifiers, Op Amps

References

- **STMicroelectronics: Our technology starts with you**
- **Op Amps (Operational Amplifiers) - STMicroelectronics**
- **ST-OPAMPS-APP - Operational amplifier and comparator application for smartphones and tablets - STMicroelectronics**
- **STMicroelectronics Trademark List - STMicroelectronics**

Manuals+,