Using TL07X Op Amps in Analog Synthesizers
Presented by Ray Wilson of MFOS

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Basic TL07X Information

Read the data sheet for full details.

- Maximum Supply V: +/-18V
- Minimum Supply V: +/-3V
- Maximum Input V: +/-15V
- Unity GBW = 3MHz.
- Current per amp ≈ 2mA.
- High input impedance (10^{12} ohm)

Output voltage swing with supply
- +/-9V ≈ +/-7V
- +/-12V ≈ +/-10V
- +/-15V ≈ +/-13.5V

Keep output load resistance above 2K for best audio results.

**ALWAYS** bypass the package with 0.1uF ceramic caps close to the power pins.

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Inverting Gain

Inverting Gain Formula

Voltage Gain = \(-1 \left( \frac{\text{RFB}}{\text{RIN}} \right)\)

Examples:
- RIN = 10K, RFB = 100K, Gain = -10
- RIN = 20K, RFB = 20K, Gain = -1
- RIN = 100K, RFB = 2K, Gain = -0.02

*Remember - Input offset voltage gets amplified too!
Offset Adjust or Biasing an Inverting Op Amp

For more information see: National Semiconductor LINEAR APPLICATIONS HANDBOOK
Linear Brief 9 - “Universal Balancing Techniques”, Aug 1969 by Robert C. Dobkin

\[
\text{Range} = \pm V \left( \frac{\text{RDIV2}}{\text{RDIV1}} \right) \times \text{Gain}
\]

\[
\text{Range} = \pm V \left( \frac{\text{RFB} \ || \ \text{RIN}}{\text{RBIAS}} \right)
\]

The gain supplied by the op amp’s inverting feedback configuration will multiply the bias voltage applied to the non-inverting input so for high gain scenarios make RDIV1 high in relation to RDIV2.

RBIAS should be selected based on the range of adjustment needed. Higher values of RBIAS will result in a smaller range of adjustment and vice versa.

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Non-Inverting Gain

Highest impedance condition with no resistor to ground.

Non-inverting Gain Formula

Voltage Gain = \left( \frac{RFB}{RGND} \right) + 1

Examples:
- RGND = 10K, RFB = 100K, Gain = 11
- RGND = 20K, RFB = 20K, Gain = 2
- RGND = 100K, RFB = 2K, Gain = 1.02

You control input impedance by R to ground.

Unity Gain Follower

Input impedance determined as in examples above.
Offset Adjust or Biasing a Non-inverting Op Amp

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\[
\text{Range} = \pm V \left( \frac{R2}{RBIAS} \right) \times \text{Gain}
\]

\[
\text{Gain} = 1 + \left( \frac{RFB}{RGND + R2} \right)
\]

RBIAS should be selected based on the range of adjustment needed. Higher values of RBIAS will result in a smaller range of adjustment and vice versa. Again note that the offset voltage appears at the output multiplied by the op amp’s gain.

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Input/Output Coupling AC vs. DC

Non-inverting Configuration AC Coupled.

Inverting Configuration AC Coupled.

Non-inverting Configuration DC Coupled.

Inverting Configuration DC Coupled.

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AC Mixer vs. DC Mixer

AC Mixer (Audio signals)

More input channels...

Input 1
10K
RIN
.1uF

Input 2
10K
RIN
.1uF

Input 3
10K
RIN
.1uF

10K

10uF (bipolar)

DC Mixer (Modulation voltages)

More input channels...

Input 1
10K
RIN

Input 2
10K
RIN

Input 3
10K
RIN

10K

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Active - Precision Full Wave Rectifier

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Comparators

Inverting Comparator

Non-inverting Comparator

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Comparator Hysteresis

Inverting Comparator With Hysteresis

Non-inverting Comparator With Hysteresis

Low impedance source expected. E.g. an op amp output.

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Pulse Width Modulation

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Capacitors to the Rescue

With high gain some op amps may oscillate at a high frequency. Placing a small value cap (10 to 100pF) across the negative feedback resistor can quell the oscillations.

To speed up your comparator's risetime place a small value cap (10 to 100pF) across the positive feedback resistor.
Integrators

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Battery Power

One nine volt battery can be used as a "split" +/−4.5V and virtual ground supply. Low current applications only.

Two nine volt batteries can be used as a "split" +/−9V supply with a much lower impedance virtual ground. Low to medium current applications only.
Active Lowpass, Highpass, and Bandpass Filters

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Online Filter Calculators You Should Know About

OKAWA Electric Design - Filter Design and Analysis

Texas Instruments FilterPro
http://www.ti.com/tool/filterpro

Texas Instruments WEBENCH Filter Designer