

# Block 24 – Wrap-up and Applications

## Student Group

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# Block 24 — Wrap-up and Applications

## 24.0 Intro

### 24.0.1 Learning objectives

After this 90-minute block, you can

- connect the different negative-feedback op-amp circuits (Blocks 21–23) into a coherent system view.
- explain how negative feedback determines gain, impedance, and linearity in practical op-amp circuits.
- select an appropriate op-amp circuit (buffer, amplifier, summing, differential, transimpedance, transconductance) for a given application.
- analyze complete signal chains consisting of several op-amp stages.
- recognize practical limitations of real op-amp circuits (supply rails, saturation, loading, offsets).
- interpret op-amp circuits as signal converters (voltage–voltage, current–voltage, voltage–current).

### 24.0.2 Conceptual overview

- All op-amp circuits in Blocks 21–23 are variations of one single idea:

a high-gain amplifier whose output is fed back in a controlled way.

- Negative feedback forces the differential input voltage  $U_{\text{D}}$  to become very small, which makes the circuit behavior depend almost entirely on external components, not on the op-amp itself.
- Resistors do not merely “limit current” here — they define signal relationships (ratios, sums, differences).
- Many circuits that look different (buffer, amplifier, converter) are mathematically and conceptually closely related.
- Thinking in terms of signal flow and conversion is the key step from circuit theory to real engineering applications.

## 24.1 Core content

### 24.1.1 From individual circuits to a system

In [Block21](#), [Block22](#) and [Block23](#), several op-amp circuits were introduced one by one. At first glance, these circuits may appear unrelated.

However, they can all be understood as special cases of the same feedback principle.

A practical electronic system rarely uses just one op-amp stage. Instead, several stages are cascaded, each fulfilling a specific role:

- Input stage: impedance matching (voltage follower).
- Scaling stage: amplification or attenuation (inverting / non-inverting).
- Combination stage: summing or subtraction (summing / differential amplifier).
- Interface stage: signal conversion (current-voltage or voltage-current).

Understanding why each stage is used is more important than memorizing formulas.

### 24.1.2 Negative feedback as an engineering tool

Negative feedback provides three essential properties simultaneously:

- **Defined gain**  
The closed-loop gain depends on resistor ratios, not on  $A_{\text{D}}$ .
- **Stability and linearity**  
Small nonlinearities inside the op-amp are strongly suppressed.
- **Impedance shaping**  
High input resistance and low output resistance can be achieved at the system level.

These properties explain why op-amps are ubiquitous in analog electronics.

### 24.2.3 Typical application patterns

Some recurring patterns appear across many applications:

- **Sensor readout**  
Sensors often deliver currents or small voltages → transimpedance amplifier → voltage amplifier.
- **Signal conditioning**  
Offset removal and scaling → differential amplifier + non-inverting amplifier.
- **Summation and mixing**  
Multiple signals combined with weighting → summing amplifier.
- **Actuator drive**  
Voltage command converted into controlled current → voltage-to-current converter.

Recognizing these patterns allows fast interpretation of unfamiliar circuits.

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