Introduction to Amplifiers

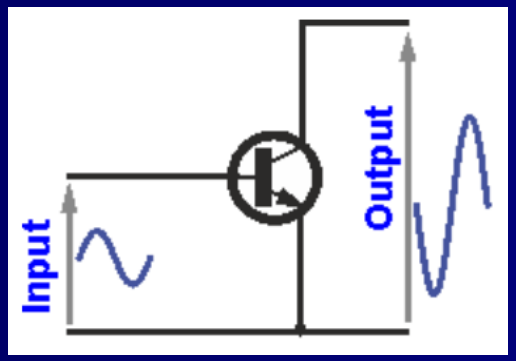
Question?

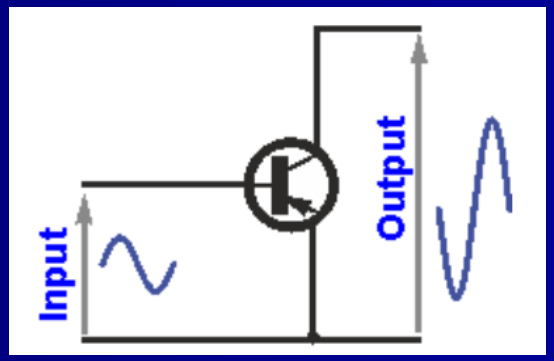
What is an Amplifier

Answer!

A device that converts a smaller input into a larger output

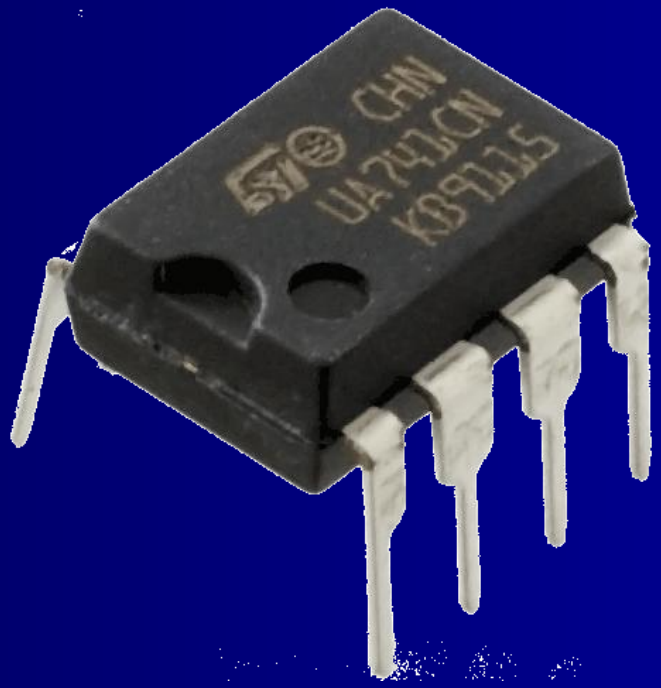
In electronics this can be a simple Transistor circuit





Industry Standard!

For many years this has been the 741 Operational Amplifier or Op Amp



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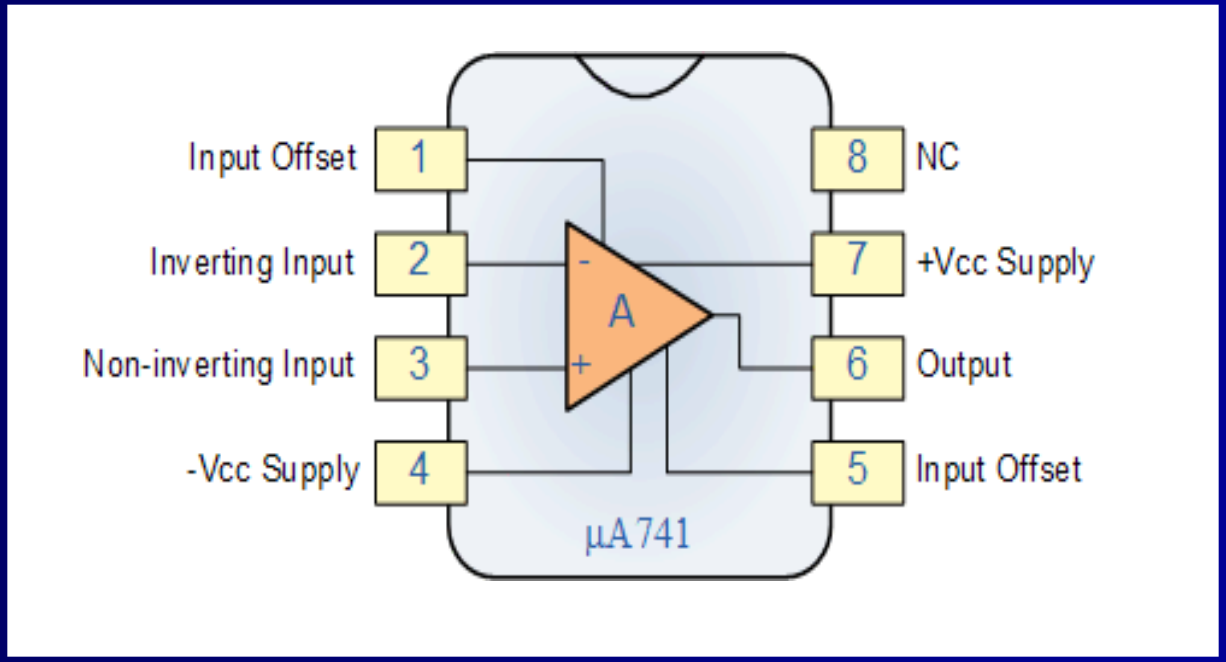
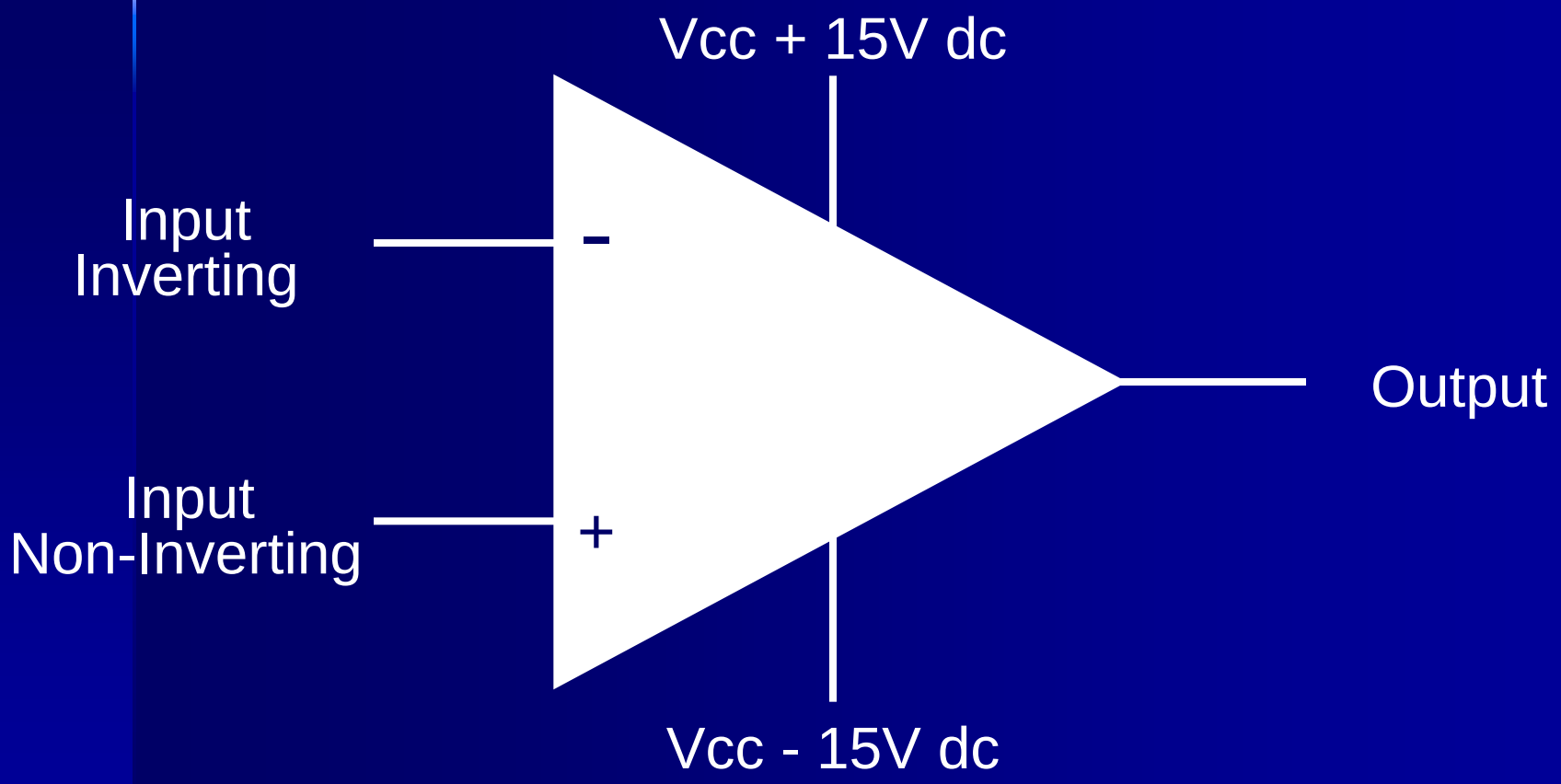
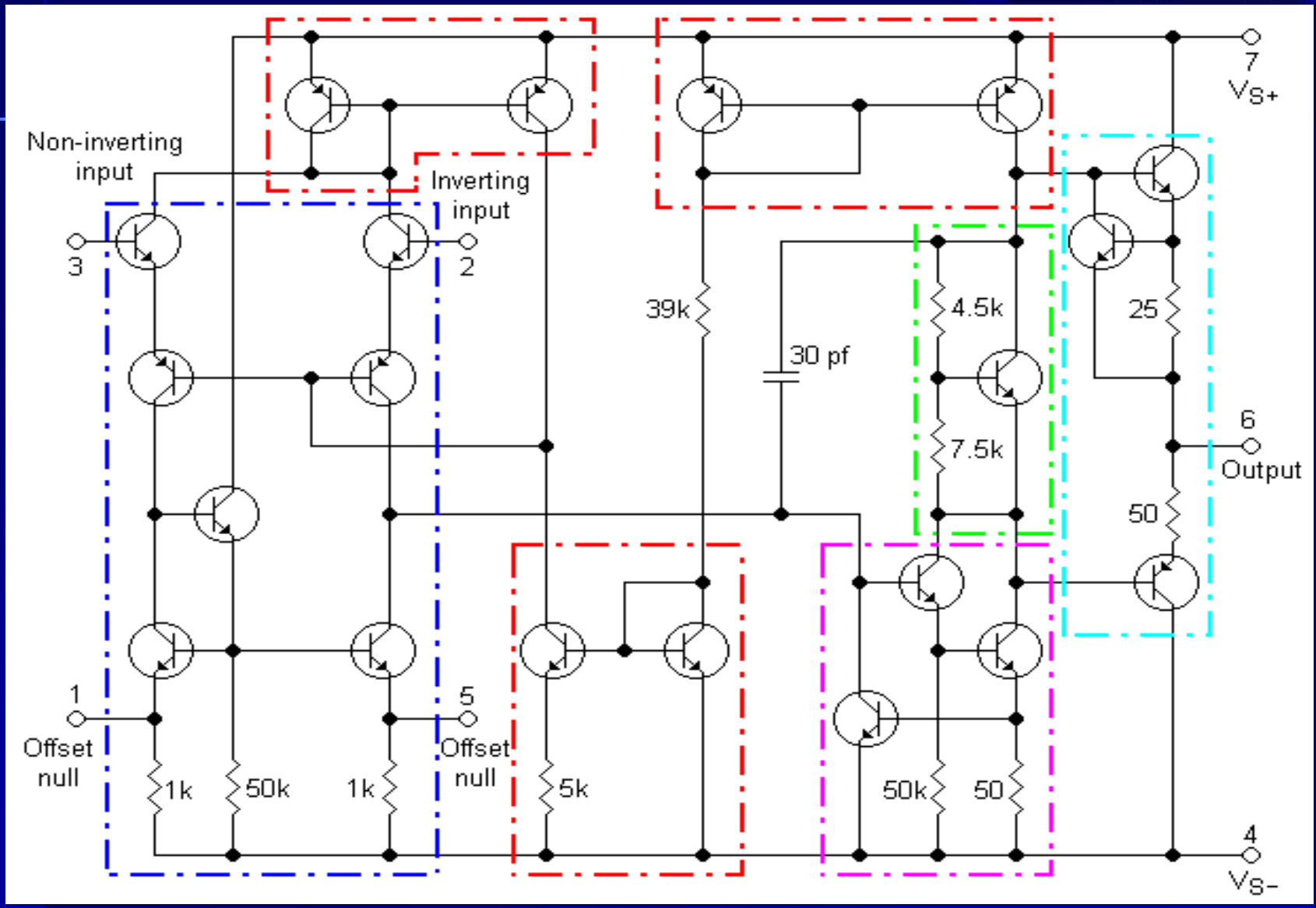


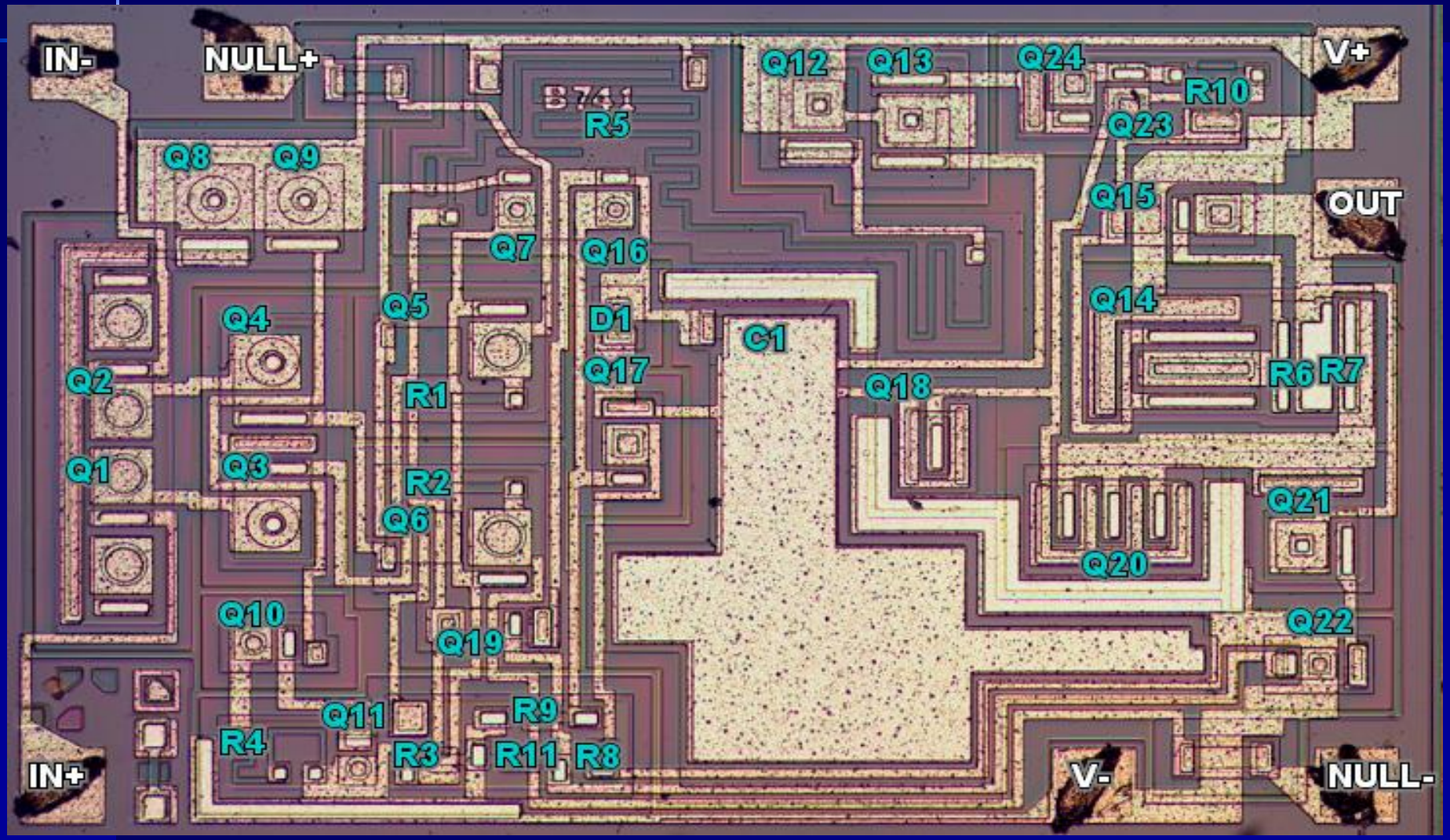
Op Amp (Symbol)



UA 741 Op Amp

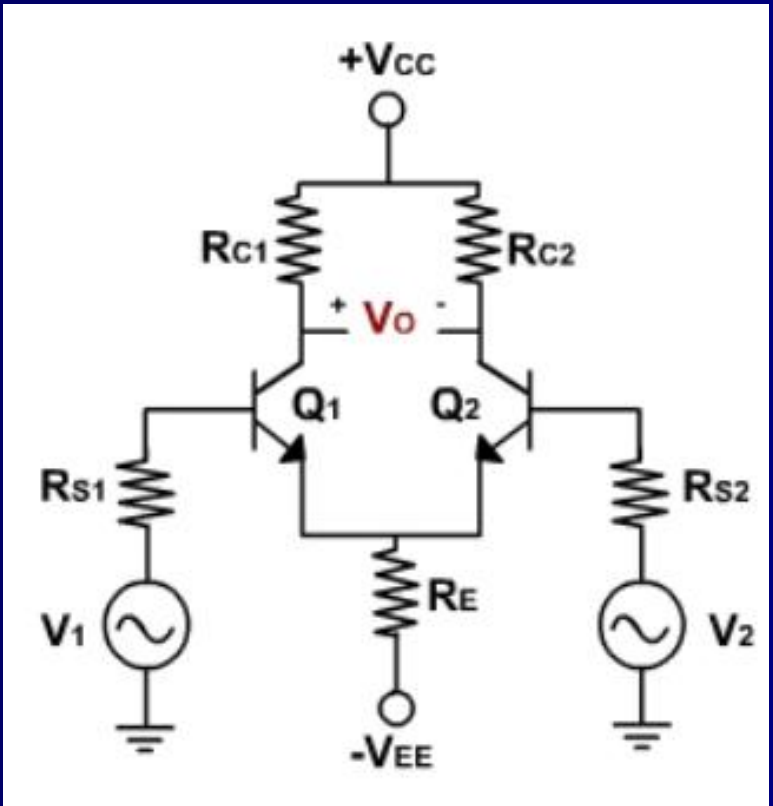

Non-inverting input
3
Inverting input
2
1
Offset null
5
Offset null
7
VS+
6
Output
4
VS-
39k
30 pf
4.5k
7.5k
25
50
1k
50k
1k
5k
50k
50

UA 741 Op Amp


IN-
NULL+
B741
R5
Q12
Q13
Q24
R10
Q23
V+
Q8
Q9
Q15
OUT
Q7
Q16
Q5
Q4
D1
C1
Q14
Q2
R1
Q17
Q18
R6
R7
Q1
Q3
R2
Q6
Q21
Q20
Q10
Q19
Q22
Q11
R9
R4
R3
R11
R8
IN+
V-
NULL-

Differential Amplifier

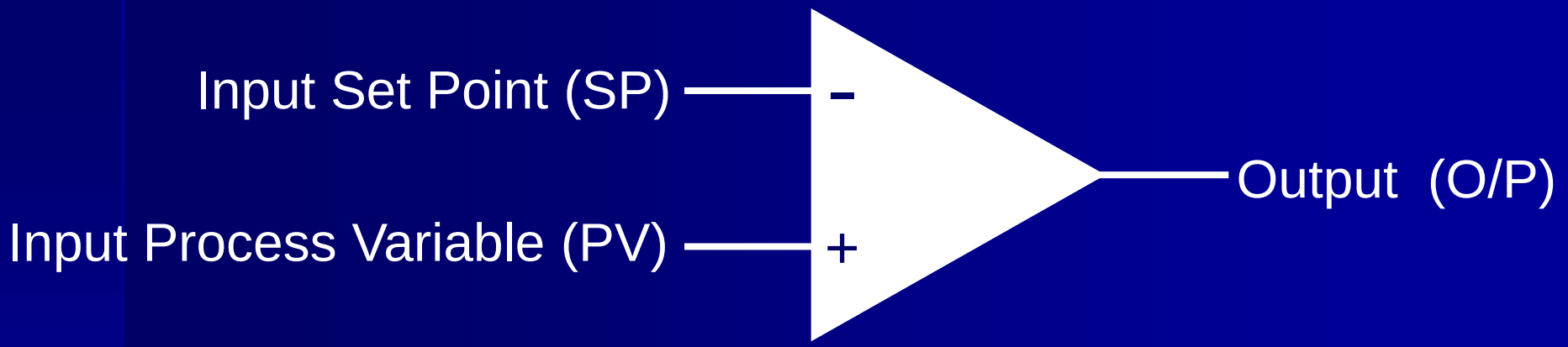
1. Dual input, balanced



Other types include:

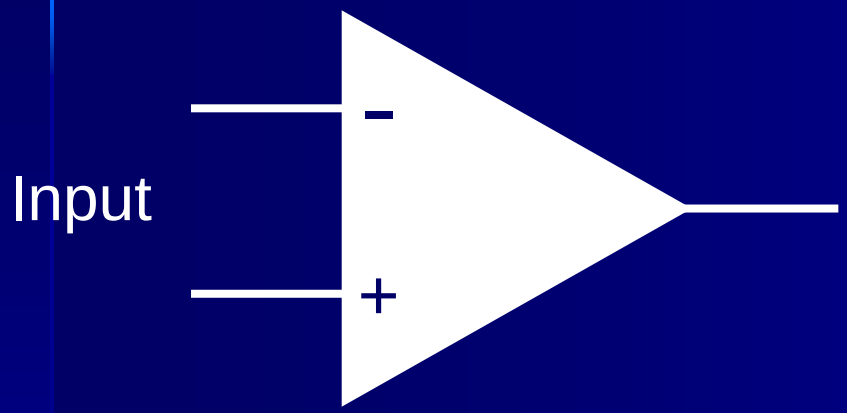
2. Dual input, unbalanced
3. Single input balanced
4. Single input unbalanced

Differential Amplifier



Compares two inputs and gives the output proportional to the difference between the two signals (error).

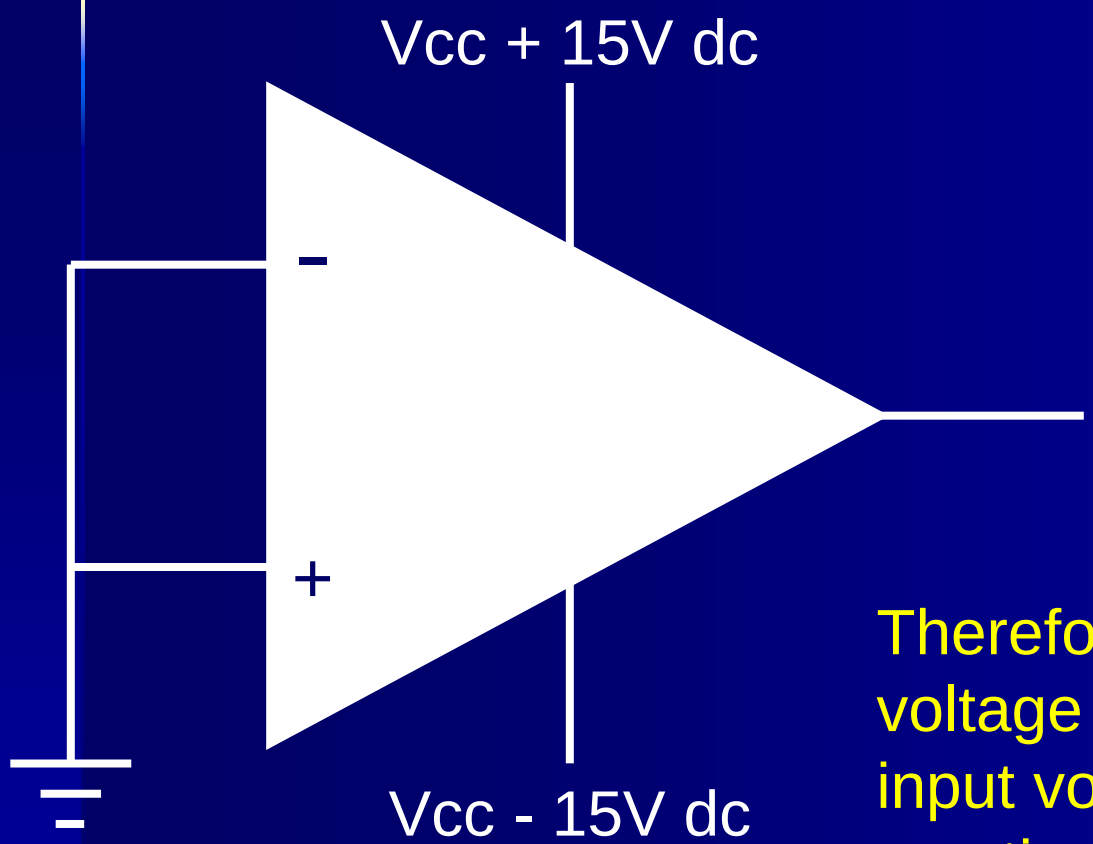
Gain (A)



$$\text{Gain} = \frac{\text{Output}}{\text{Input}}$$

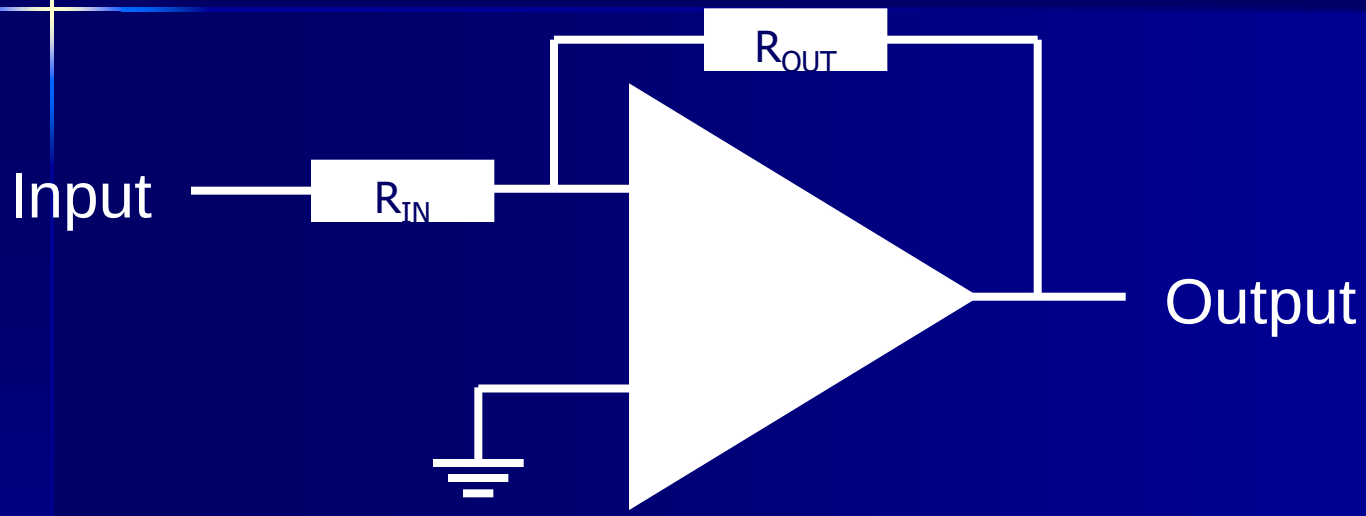
In open-loop gain “no feedback” (i.e. no connection between the output of the op-amp and any of its inputs), the op-amps data sheet specifies that the gain of the op-amp when used in ‘open-loop’ mode would have an infinite gain.

Voltage Gain (A_v)



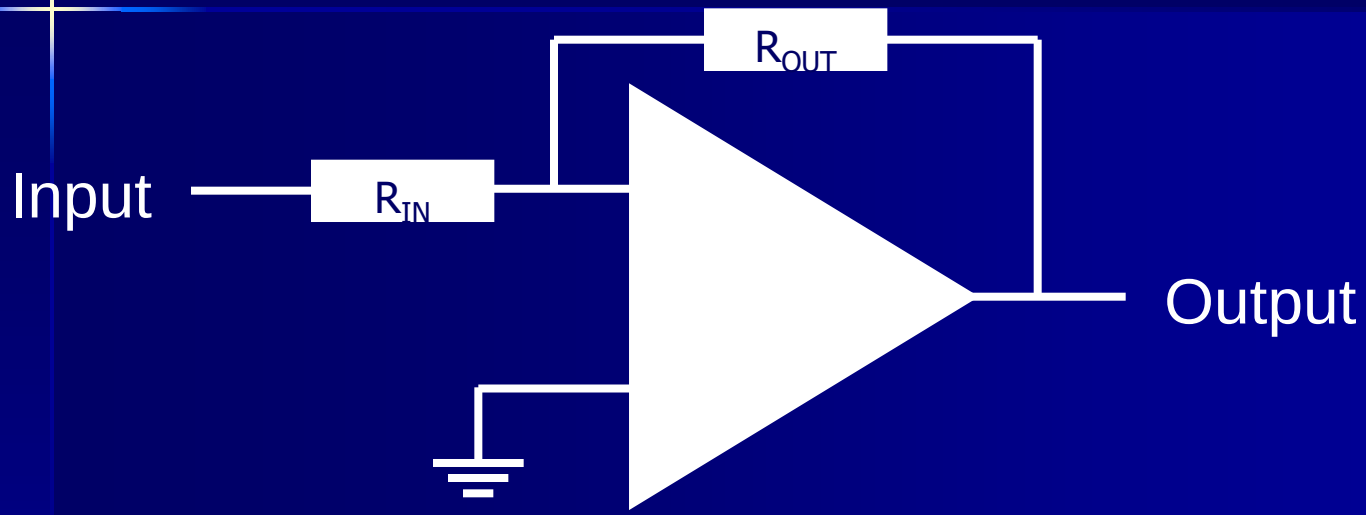
Therefore a significant output voltage would result from an input voltage of virtually zero. In practice, the open-loop gain is usually >100,000

Feedback



Connecting the output to the input via resistors we can feed a portion of the output back to the input, this will reduce the gain of the amplifier but will give us more control of the output. The ratio R_{OUT} / R_{IN} of the resistor values will now dictate the gain of the amplifier.

Feedback



Feedback' means adding a fraction of the output signal to the input signal. When this fraction is returned in phase (in step) with the input signal, it is called 'positive feedback'. When it is out of phase with the input signal, it is called negative feedback.

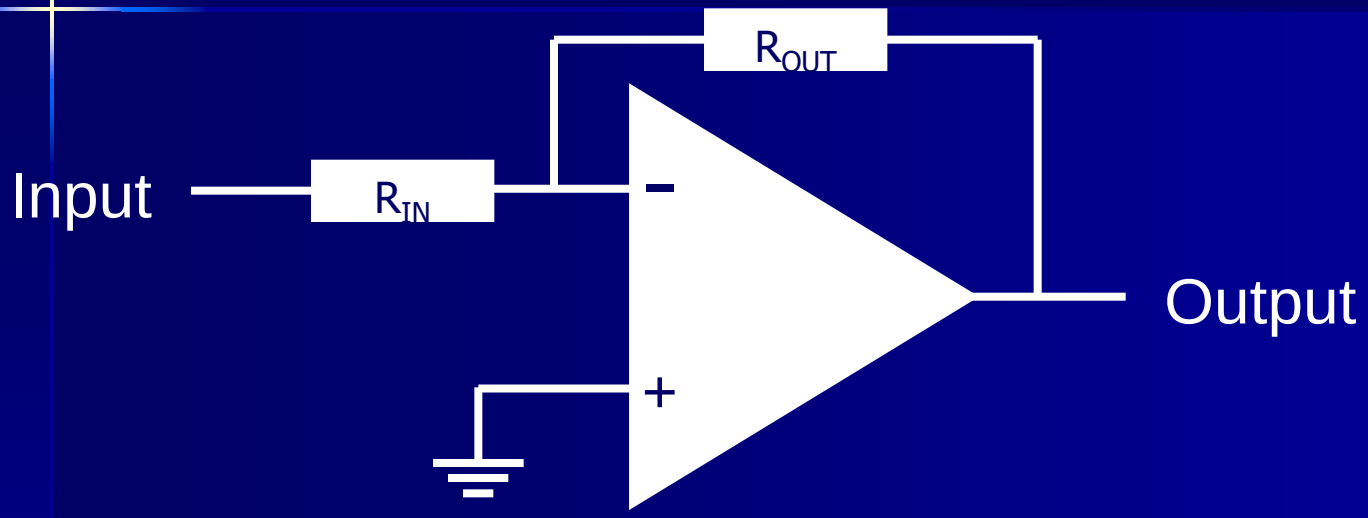
Positive Feedback

Usually causes problems in audio systems. An everyday example is where a microphone is placed too close to a loudspeaker system. A quiet sound picked up by the microphone is amplified and played through the loudspeakers. The microphone picks up some of this, adding to the original sound source and so the sound from the loudspeakers gets louder, as does the proportion picked up by the microphone …… The result is a high-pitched squeal. Positive feedback usually produces either oscillation, as in the microphone example, or saturation, where the output voltage cannot go any higher (or lower) because of power supply limitations.

Negative Feedback

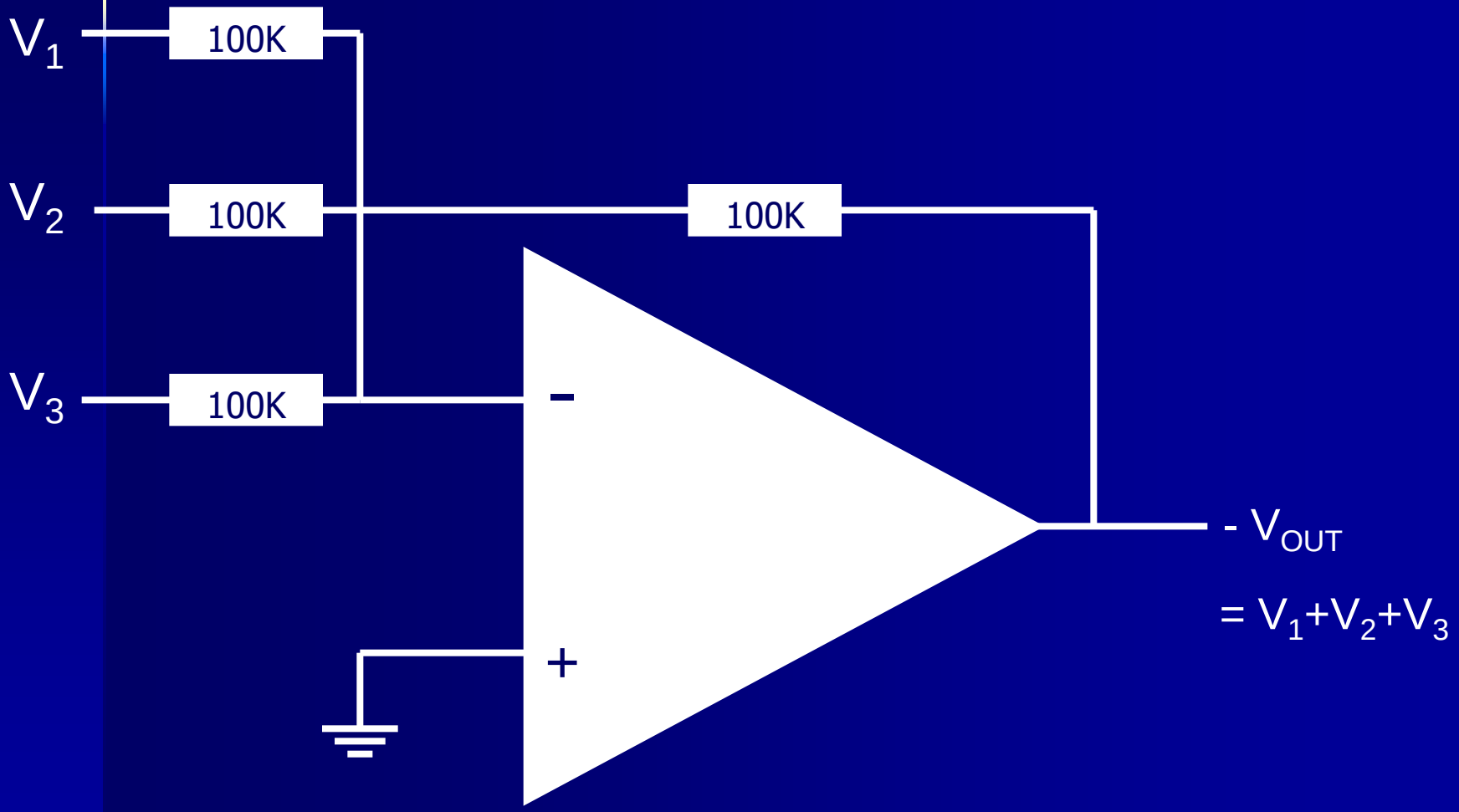
The large open-loop gain of the op-amp, makes it an extremely unstable device. Changes to power supply voltage, input voltage, device temperature or electrical noise can cause instability and make the output unpredictable. Stability can be improved by introducing negative feedback. This uses part of the output signal to reduce the input signal and, in the process, keeps the amplifier under control. In contrast to the example of positive feedback, negative feedback is used in ‘noise-cancelling headphones’. Here, a microphone picks up sounds from the surroundings. An audio system plays an out-of phase version of these through the headphones to cancel out the external sounds

Negative Feedback

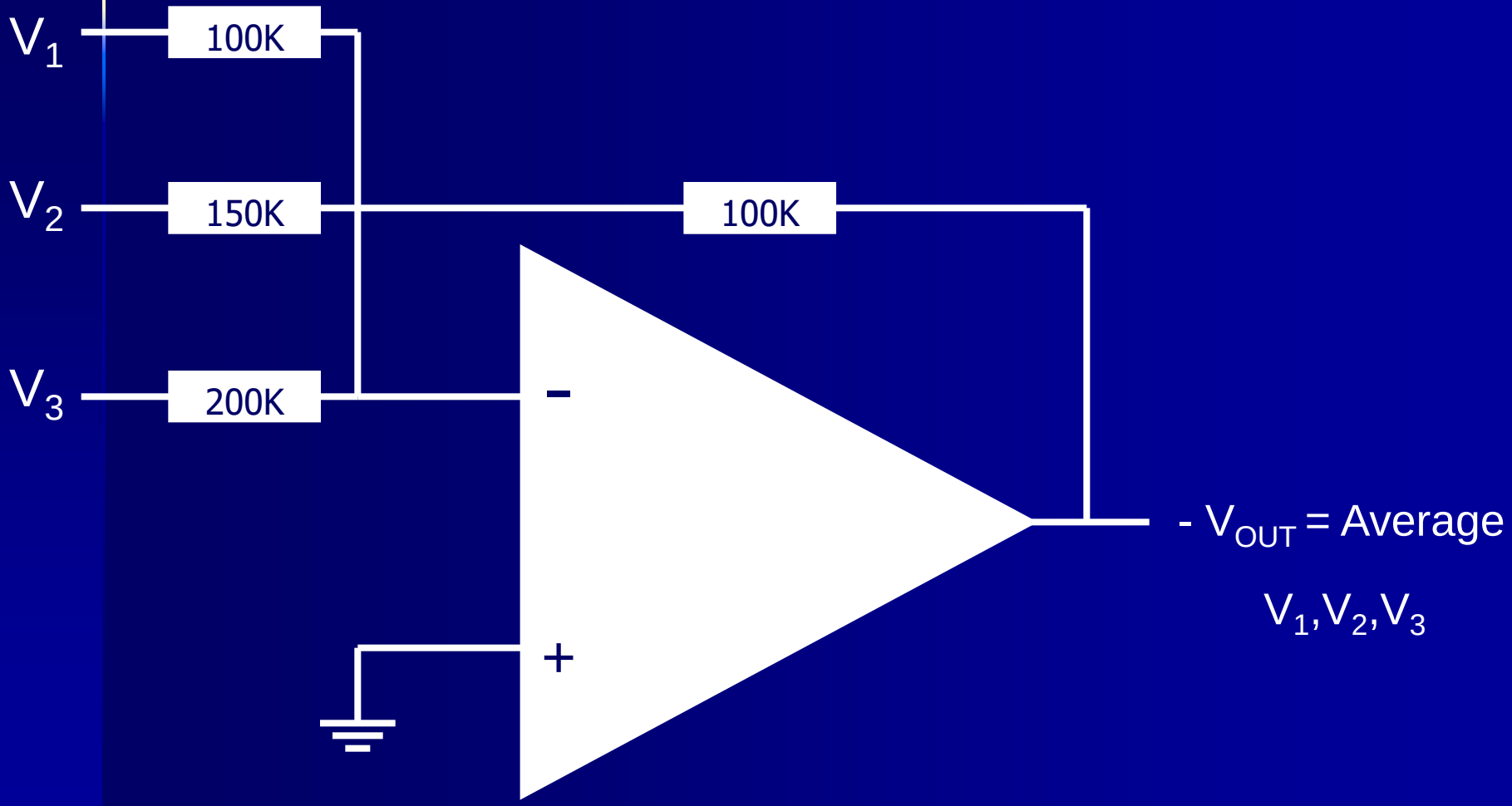


By utilising the Inverting input of the amplifier any sample fed back will be in anti-phase to the original signal and the gain will be proportional to the output / input resistor ratio.

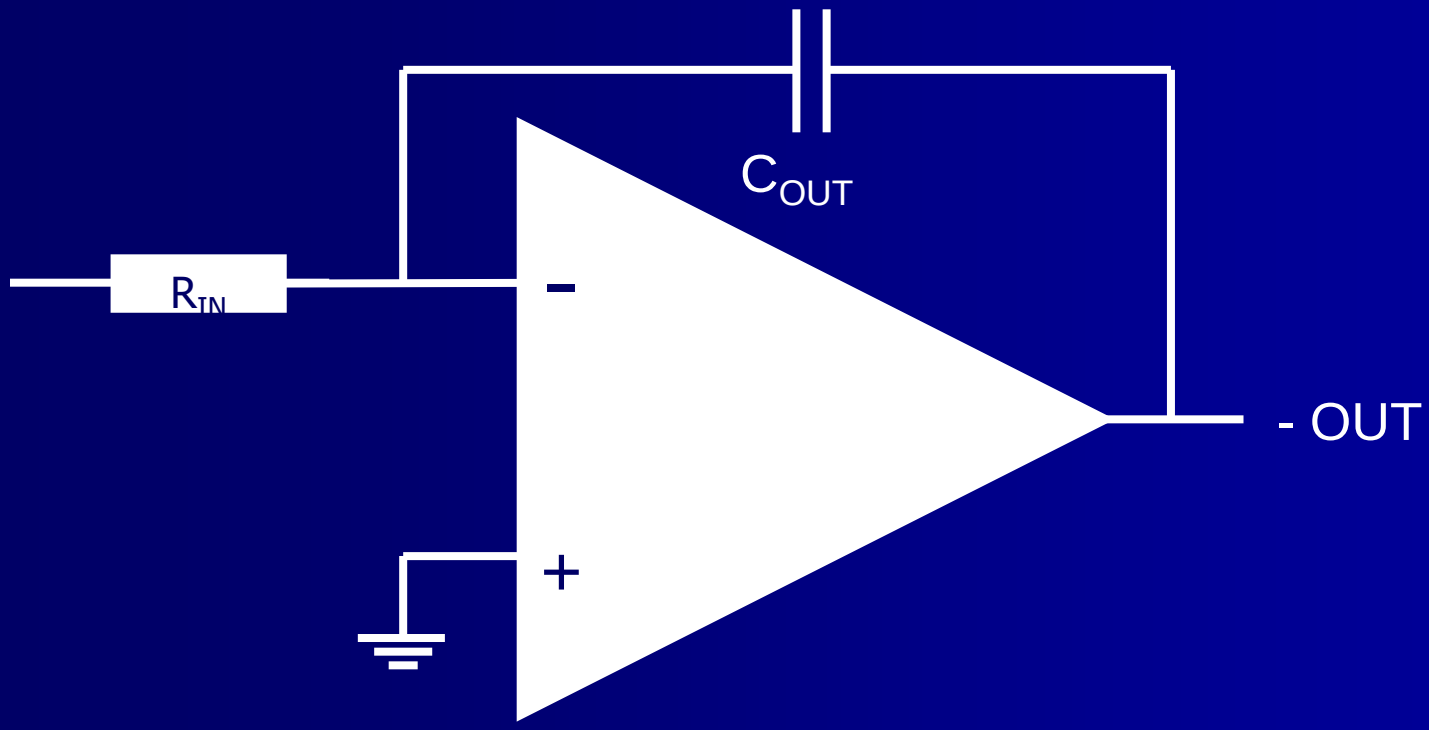
Summing Amp



Scaling Amp

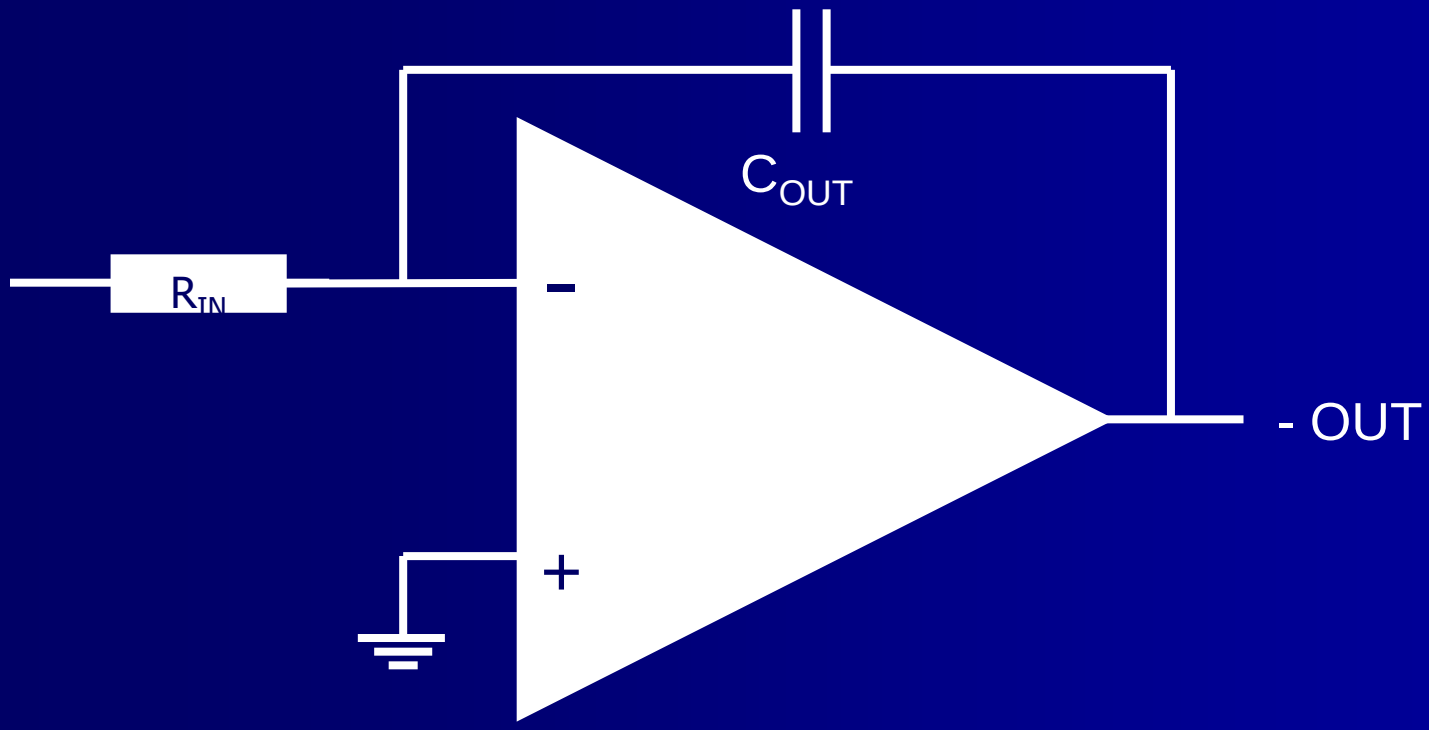


Integrator Amp



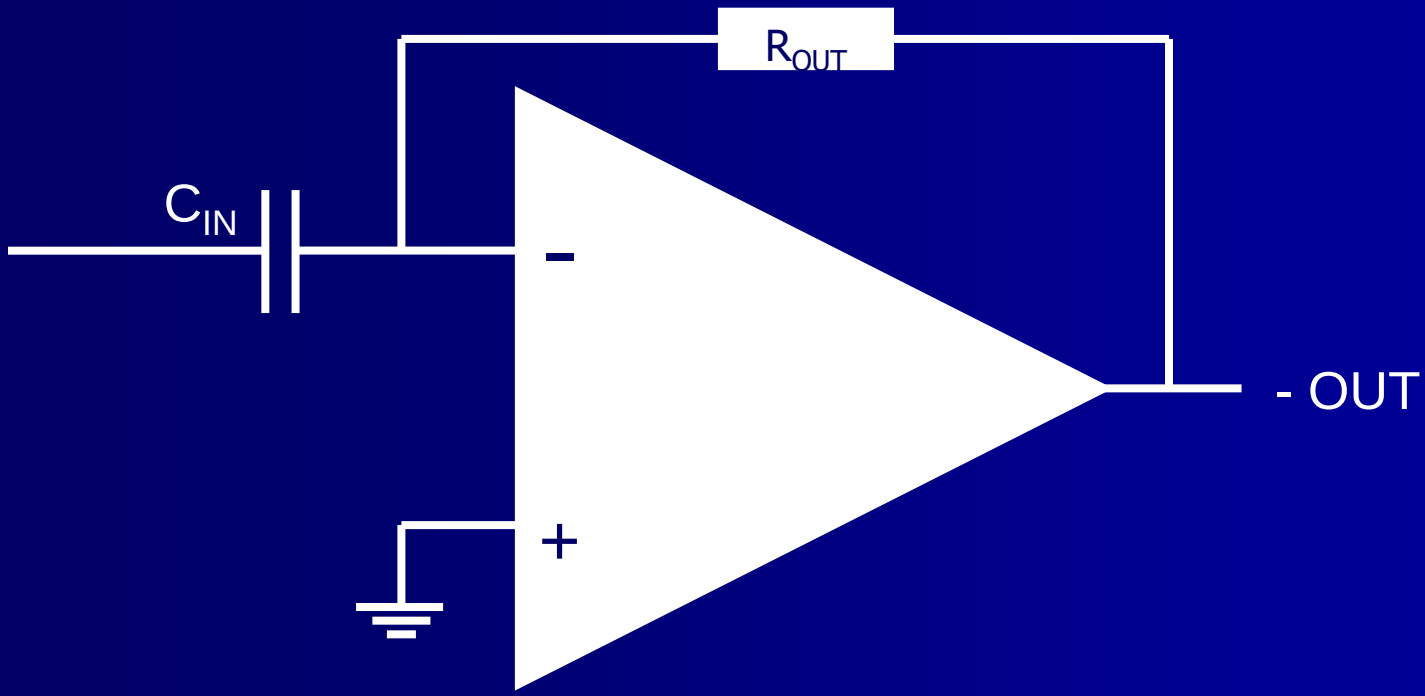
By reconfiguring the feedback loop to incorporate a capacitor from the output, the amplifier will perform the mathematical function of integration.

Integrator Amp



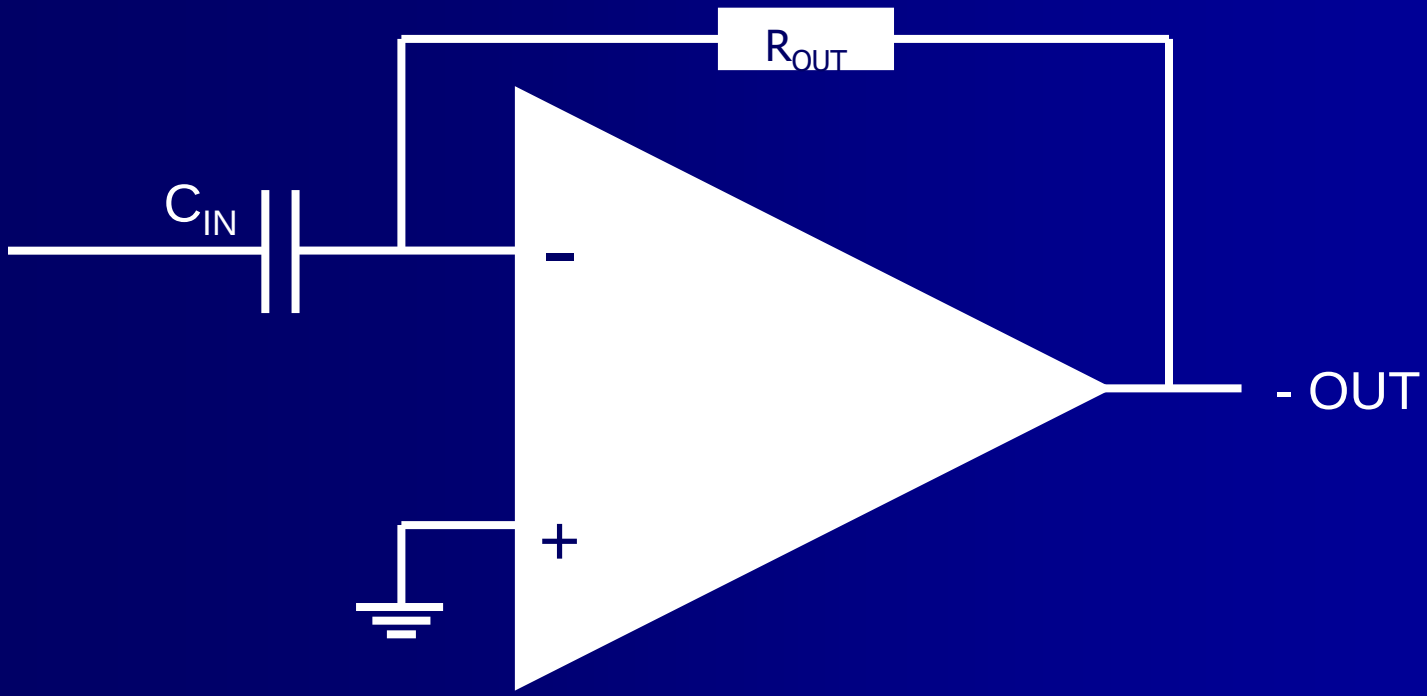
The integrator Op-amp produces an output voltage that is both proportional to the amplitude and duration of the input signal

Derivative Amp



By reconfiguring the feedback loop again this time putting a capacitor on the input, the amplifier will perform the mathematical function of Differentiation.

Derivative Amp



The Derivative amp produces an output which is directly proportional to the input's rate-of-change with respect to time. The faster the change to the input, the faster the output change in response.