University of Glasgow

UESTC 3003: Electronic System Design

Static Errors

Lecture 2.1: Revision of Op Amps

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WORLD CHANGING GLASGOW

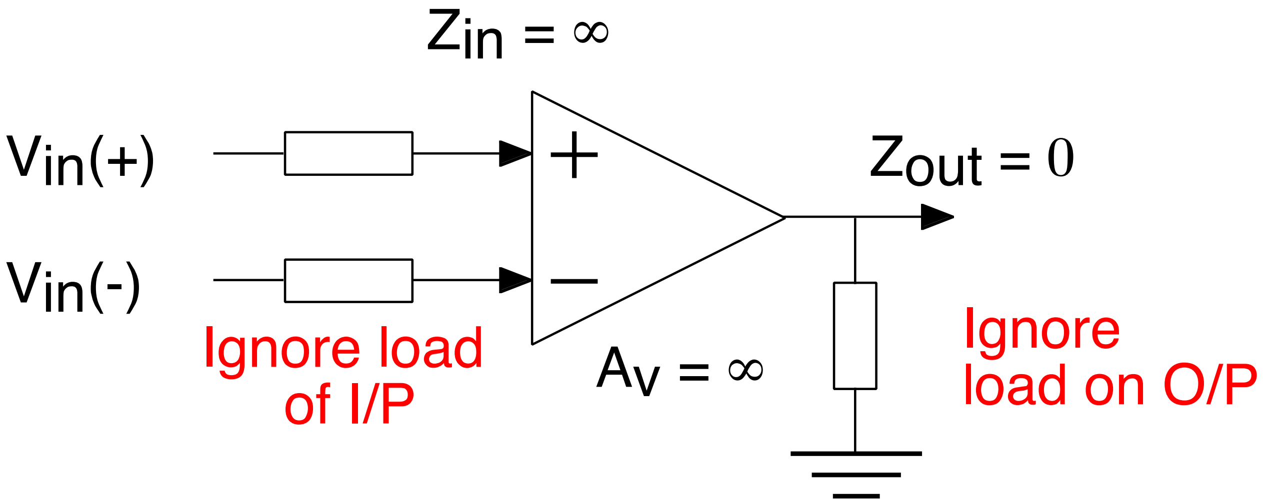
System Engineering : Signal Conditioning

- In **Electronic System Design** we will consider how to provide the best possible input signals to the system. This means signals that are:-
  - **Accurate**: providing the most accurate signal to the system
  - **Clean**: providing the system with the cleanest, lowest noise signal
  - **Immune:** (from disturbance): signals remain accurate and clean when there is interference
- Our course will explore how to deal with low level signals and condition them for the system to use (probably in a digital process)

"Pray, Mr. Babbage, if you put into the machine wrong figures, will the right answers come out?" ... I am not able rightly to apprehend the kind of confusion of ideas that could provoke such a question.
— Charles Babbage, *Passages from the Life of a Philosopher* Source Wikipedia

Opamps Revision

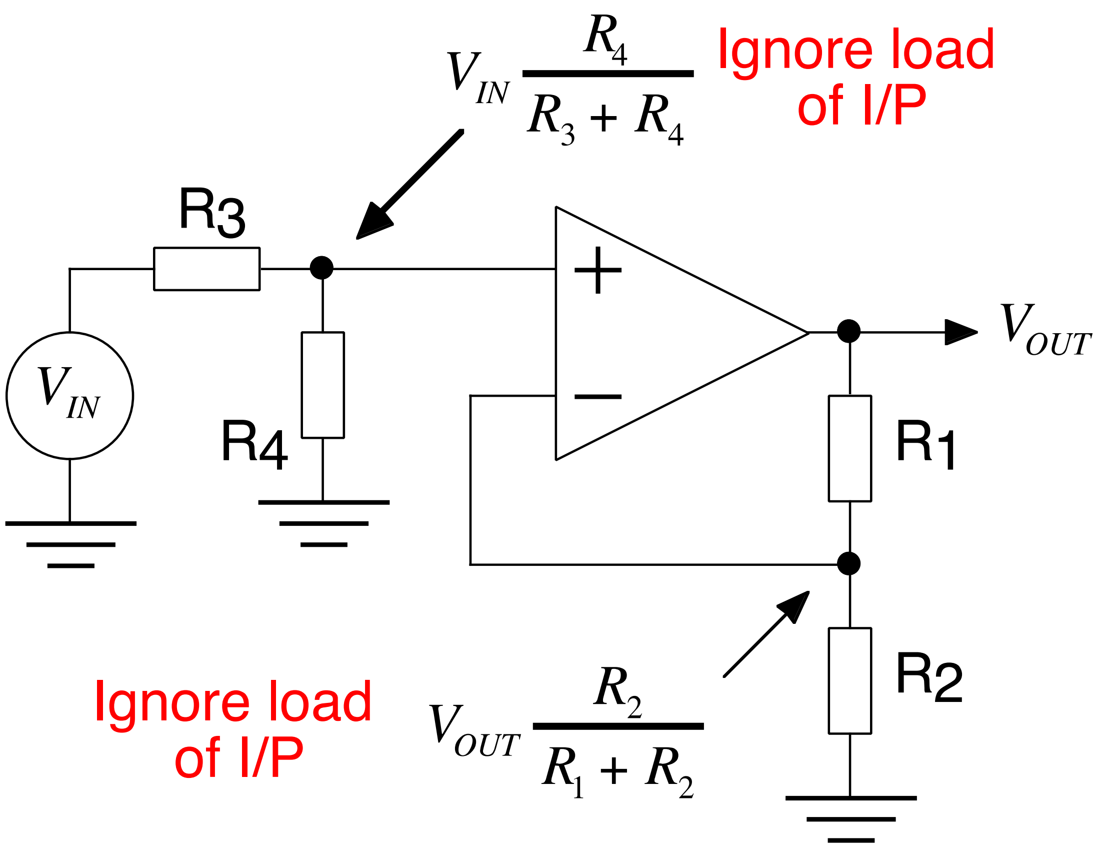
- Analogue design simplest using opamps
- Start with perfect opamp



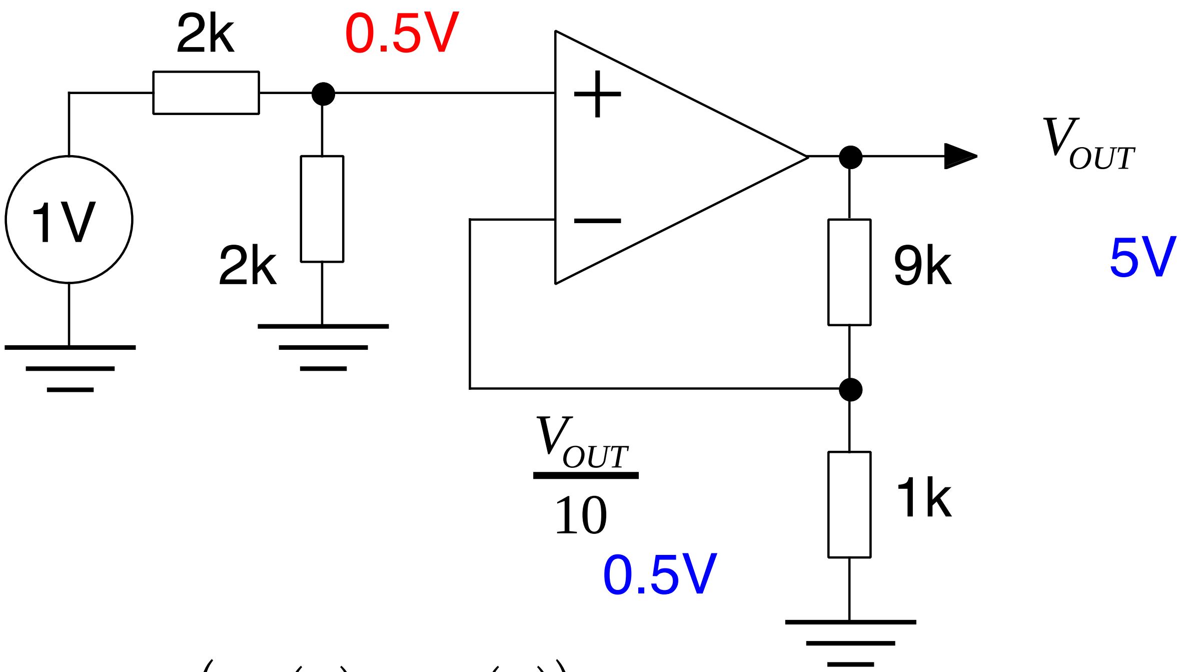
Virtual Earth

$$V_{OUT} = \infty\left(V_{IN}(+) - V_{IN}(-)\right)$$

Perfect opamp calculations (Revision)



Negative Feedback



$$V_{OUT} = \infty\left(V_{IN}(+) - V_{IN}(-)\right) \quad = \infty \bullet 0$$

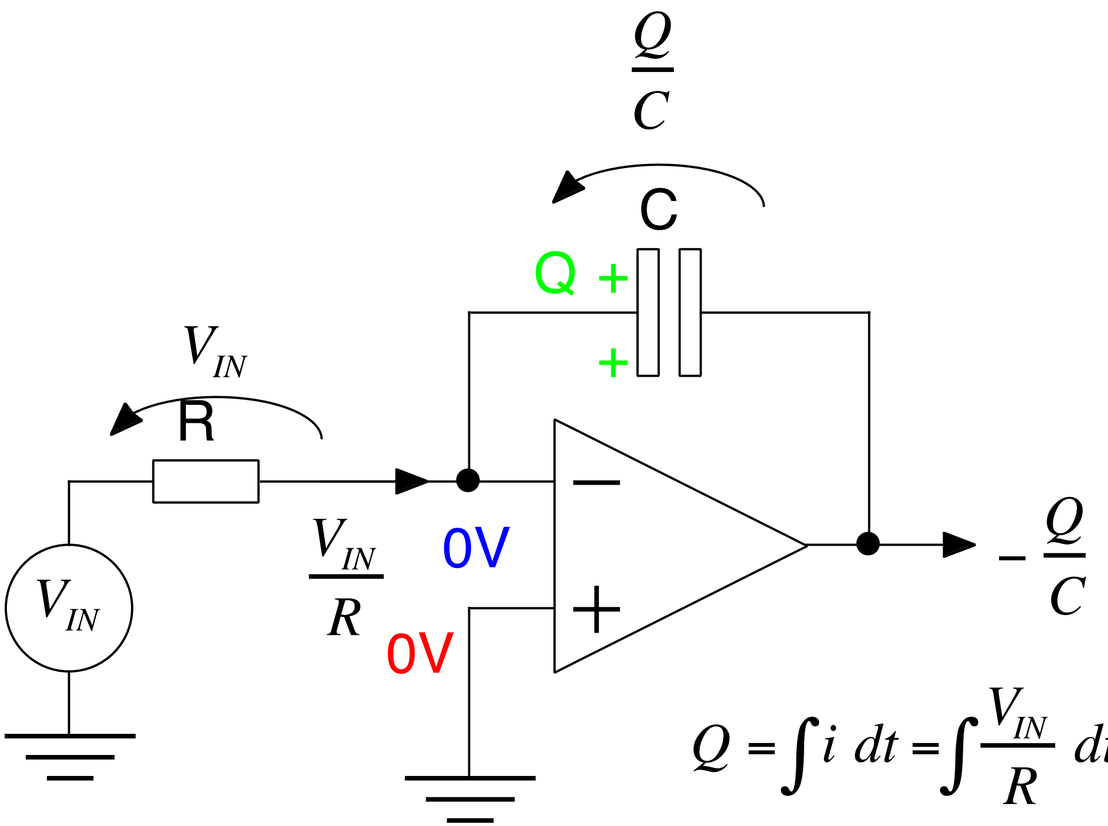
Negative Feedback

- **Calculate voltage at (+), (–) inputs as a function of**
  - Input voltage
  - Output voltage

- **Output does whatever it takes to make input voltages (+) & (–) equal**

- **Inputs do not directly change anything**

Example 2: The Integrator



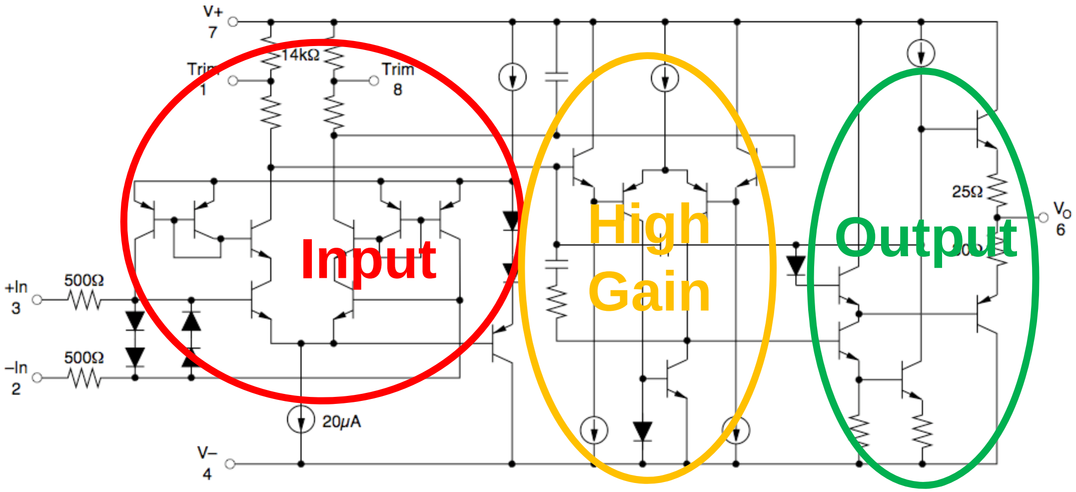
$$Q = \int i \; dt = \int \frac{V_{IN}}{R} \; dt \;\Rightarrow V_{OUT} = -\int \frac{V_{IN}}{CR} \; dt$$

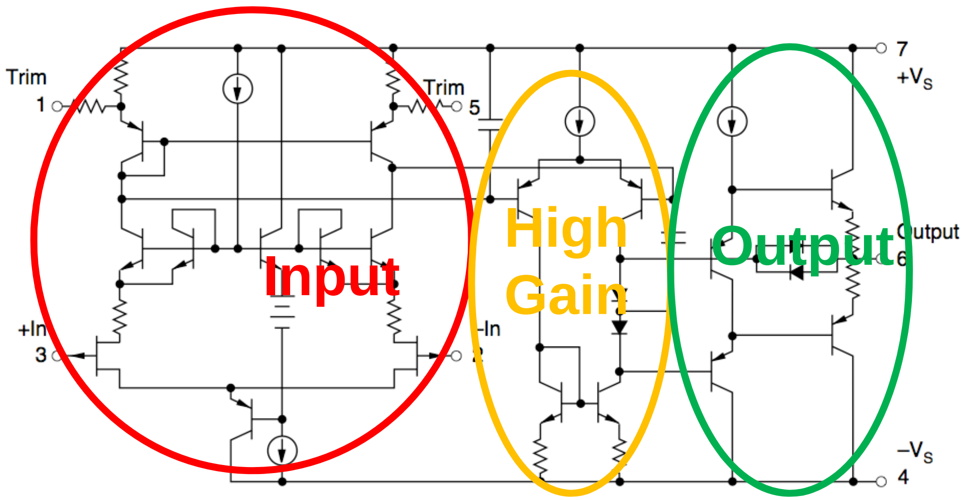
Opamps are <u>not</u> perfect

- Input offset voltage
- Input currents (“Bias” and “Offset”)
- Speed
  - Gain-Bandwidth product
  - Slew Rate
- Noise
- Other
  - CMRR, R_{OUT}, PSRR, Gain, Power…….

Opamps are complicated

⇒ **Compare (standardized) datasheet parametrics … (*Vos, Ib, Ios*)**





… don't try and compare schematics; leave that to experts!

Perfect opamp calculations are easy…
(but real opamps are more difficult…)

Method:

- Opamps are **<u>not</u>** perfect:

  Form a model of an imperfect opamp which is a perfect opamp
  PLUS additional (ideal) voltage and current sources

- Calculations still (relatively) easy (perfect opamp plus linear components)
- Source values become optimisation parameters for system
- Different circuits can be compared using standard parameters

System Design = Choice

- <u>No</u> opamp is perfect
- Choice of hundreds of different OpAmps
- Pennies (4p for a dual) -> £371 each
    - RS sell a reduced selection of the best opamps in a limited range of grades (4777)

Design for function (e.g. amplifier) → Analyse errors → Choose components to meet specification

Tools to help you…

- You **cannot** get a computer to do the design for you…
- …but you **can** get it to check if the circuit operates the way YOU wanted it to
- **S**imulated **C**ircuit **P**rogramme with **I**ntegrated **C**ircuit **E**mphasis (**SPICE**)
  - many different variants derived from UC Berkeley :
- PSPICE, HSPICE, ….
- We will use LTSpice or Orcad/PSpice
- - **It is a free download** from Linear Technology Inc (Mac & PC)
- - It consists of Schematic Capture, Simulator, and Waveform engine
- It is one of the simplest SPICE versions I have found
- http://www.linear.com/designtools/software/#LTspice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