University of Glasgow

UESTC 3003: Electronic System Design

Static Errors
Lecture 2.1: Revision of Op Amps

Dr Sajjad Hussain
Thanks to Prof. Duncan Bremner

WORLD CHANGING GLASGOW

Sajjad.Hussain.2@glasgow.ac.uk

System Engineering : Signal Conditioning

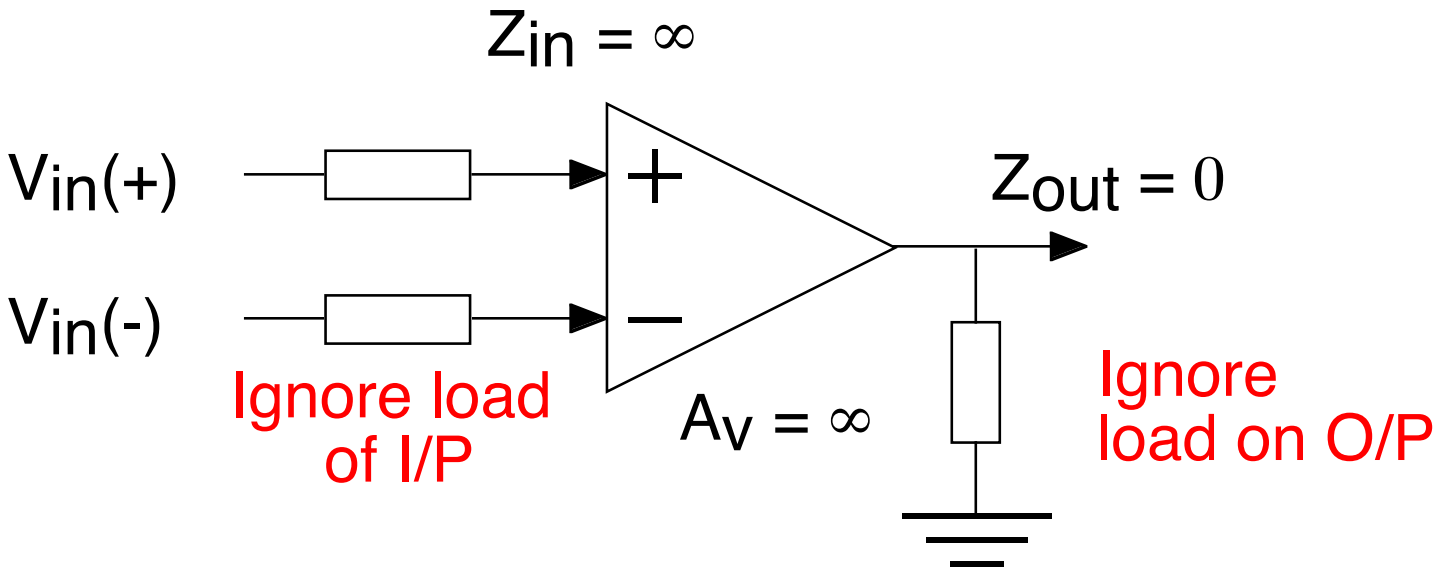
- In **Electronic System Design** we will consider how to provide the best possible input signals to the system. This means signals that are:-
  - **Accurate**: providing the most accurate signal to the system
  - **Clean**: providing the system with the cleanest, lowest noise signal
  - **Immune:** (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

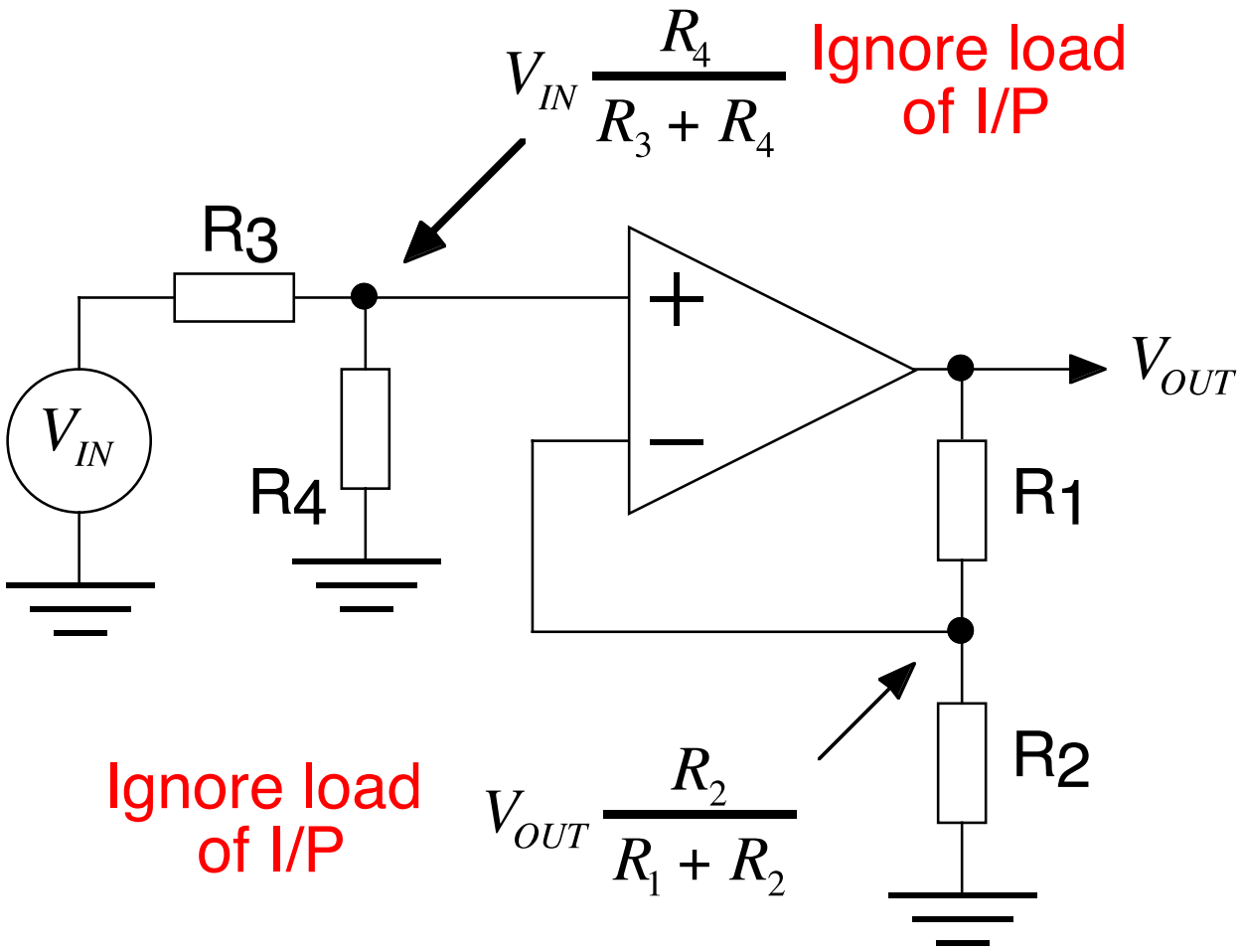
- Analogue design simplest using opamps
- Start with perfect opamp



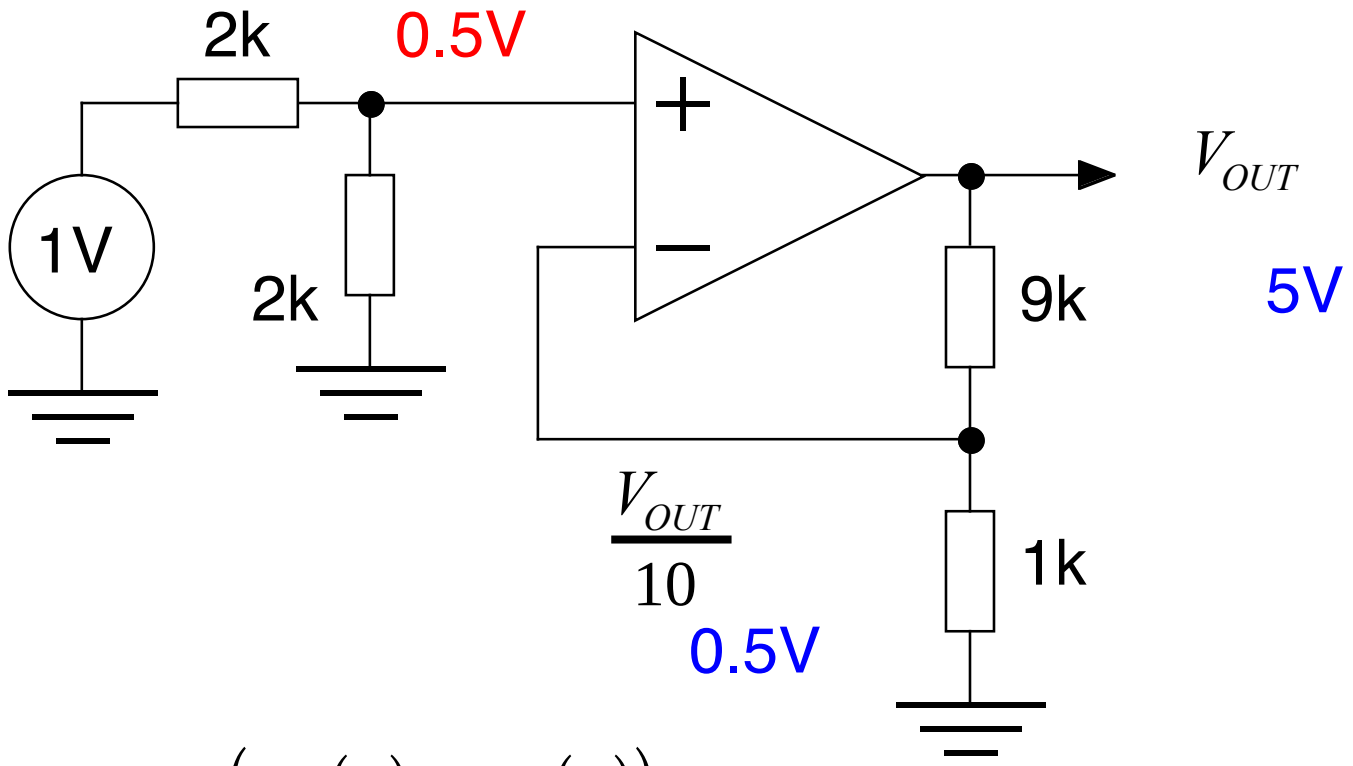
Virtual Earth

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

Perfect opamp calculations (Revision)



Negative Feedback



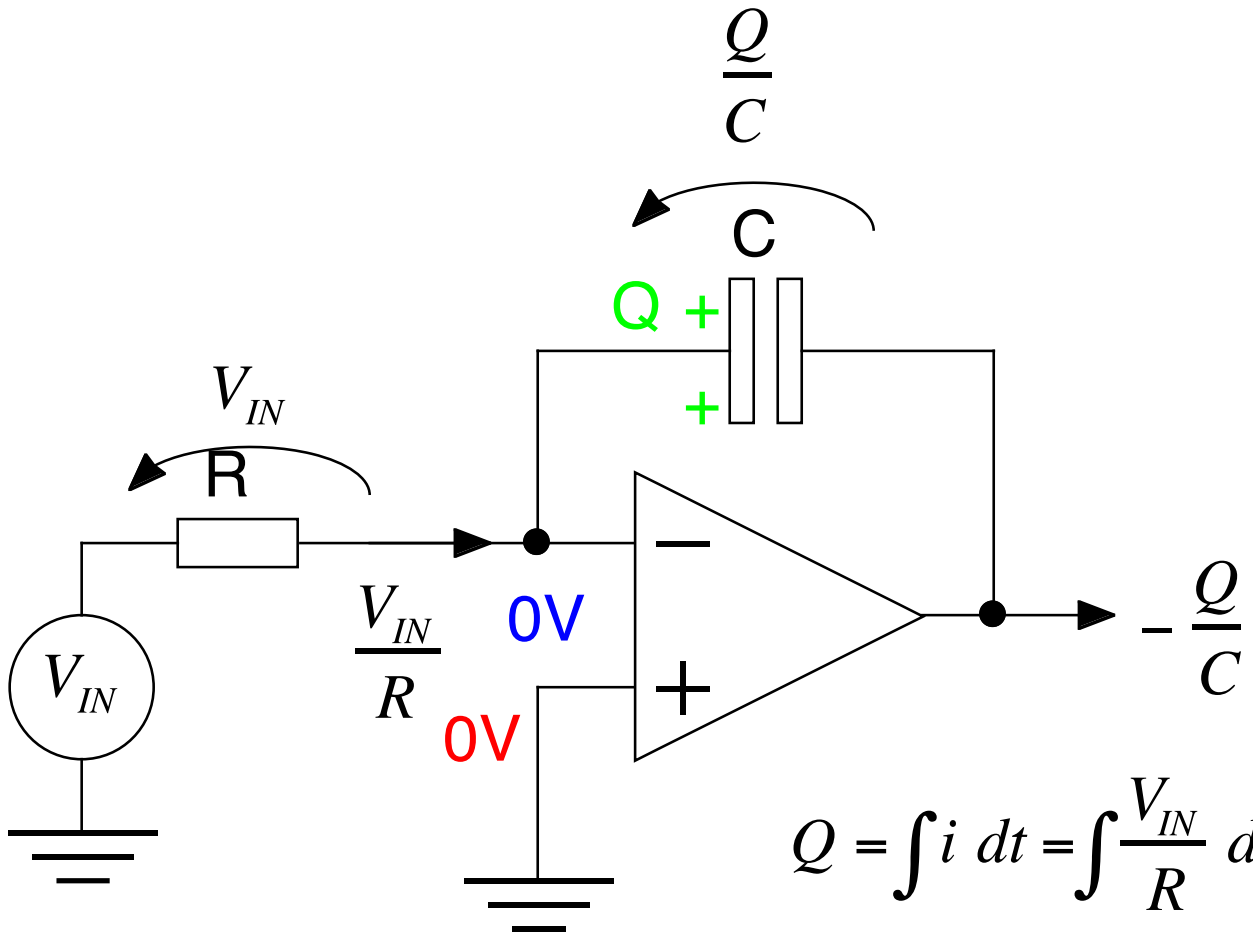
$$V_{OUT} = \infty\left(V_{IN}(+) - V_{IN}(-)\right) \quad = \infty \bullet 0$$

University of Glasgow

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



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

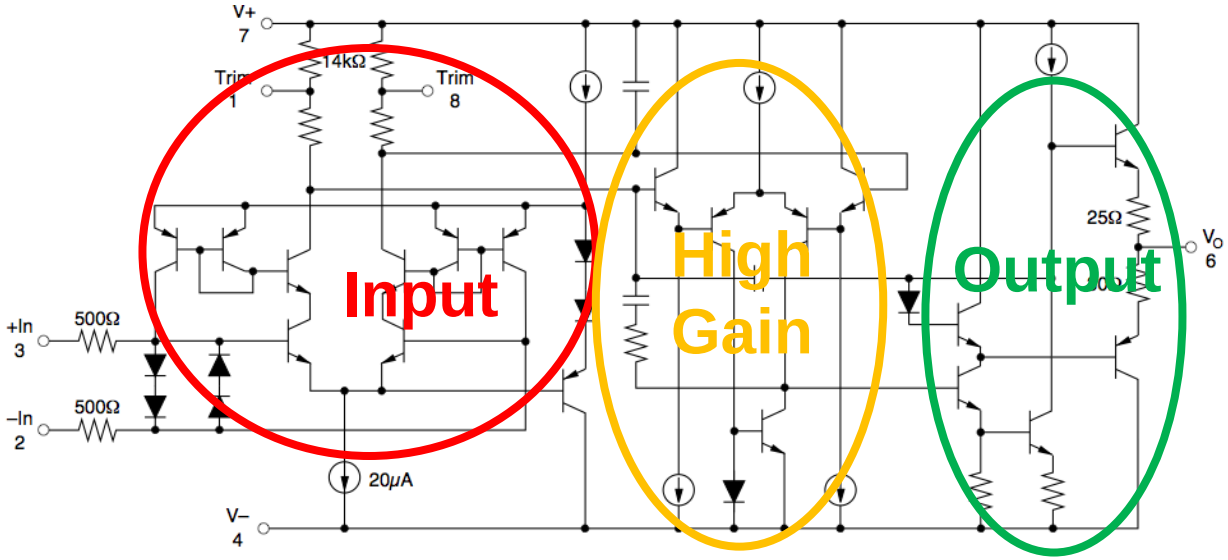
University of Glasgow

Opamps are not perfect

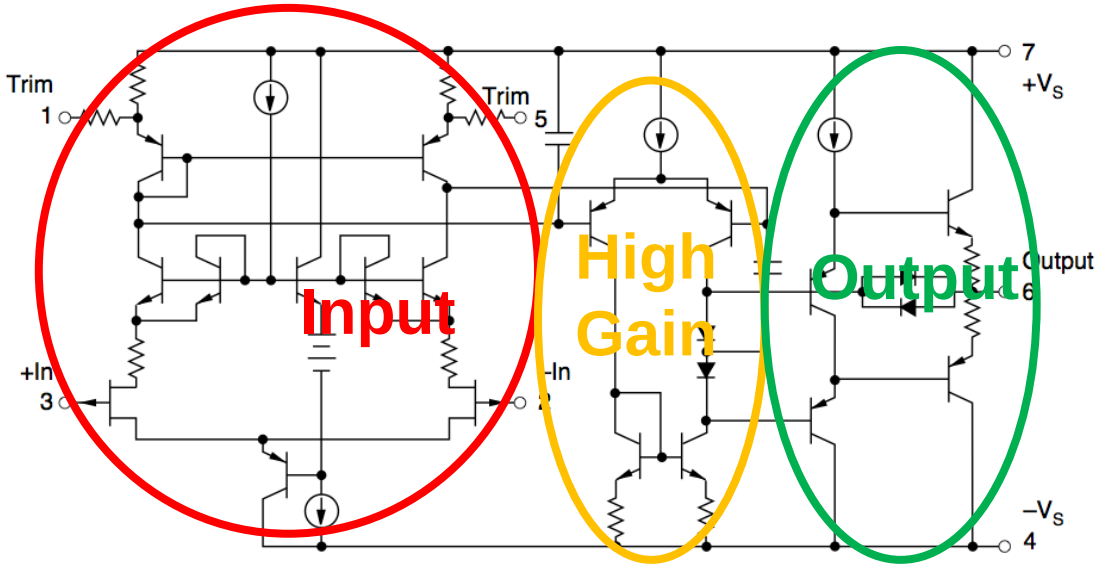
- Input offset voltage
- Input currents (“Bias” and “Offset”)
- Speed
  - Gain-Bandwidth product
  - Slew Rate
- Noise
- Other
  - CMRR, R_{OUT}, PSRR, Gain, Power…….

University of Glasgow

Opamps are complicated



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



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

University of Glasgow

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

Method:

- Opamps are **not** perfect:

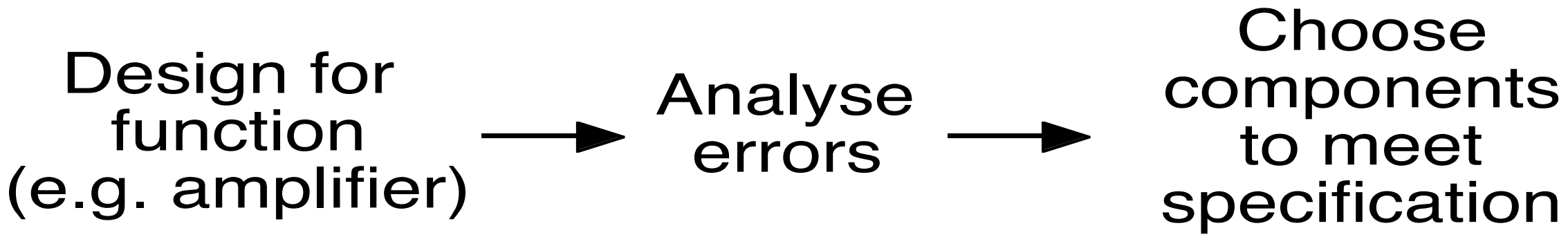
  Form a model of an imperfect opamp which is a perfect opamp
  PLUS additional (ideal) voltage and current sources

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

University of Glasgow

System Design = Choice

- No 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)



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


University of Glasgow
Thank you
谢谢
INSPIRING PEOPLE
#UofGWorldChangers
@UofGlasgow