Operational Amplifiers

Session 6f for Electronics and Telecommunications
A Fairfield University E-Course
Powered by LearnLinc

Module: Semiconductor Electronics
(in two parts)

- Text: “Electronics,” Harry Kybett, Wiley, 1986, ISBN 0-471-00916-4
- References:
  - Electronics Tutorial (Thanks to Alex Pounds)
  - Electronics Tutorial (Thanks to Mark Sokos)
- 5 - Semiconductors, Diodes and Bipolar Transistors
  - 5 on-line sessions plus one lab
- 6 - FETs, SCRs, Other Devices and Amplifiers
  - 5 on-line sessions plus one lab
- Mastery Test part 3 follows this Module

Section 6: FETs, SCRs, Other Devices and Operational Amplifiers

- 0BJECTIVES: This section reviews additional important semiconductor devices and their applications. The Operational Amplifier is also studied.

Section 6 Schedule:

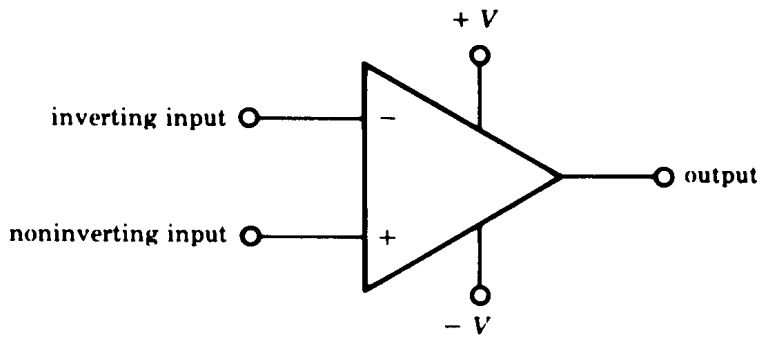
Session 6a	01/15	Field Effect Transistors	Kybett pp 70 – 77, pp 201-209
Session 6b	01/20	Transistors as a switch	Kybett pp 78 –107
Session 6c	01/22	SCR's, Triacs and UJTs	Notes
Session 6d	01/27	Class A, B, and C Amplifiers	Notes
Session 6e (no class Monday)	01/29	Q & A	
Session 6e (Lab - 02/08, Sat.)	**02/05**	**Operational Amplifiers**	**Kybett pp 209-215**
Session 6f (Quiz 6 due 02/23)	02/10	Review for Quiz 6 (no class 2/17 or 2/19)	
Session 6g	02/24	Discuss Quiz 6	
Session 6h	02/26	Review for MT3	
MT3	03/01	MT3 Exam	
Session 6i	03/10	Discuss MT3	

Amplifier Summary

Class	Duty Cycle	Efficiency	Application
A	100%	Low	Linear small signal
B (AB)	50%	~ 50%	Linear power
C	< 50%	~ 80%	RF Power
D	High speed switching	~ 85%	DC power supplies and Low frequency linear power

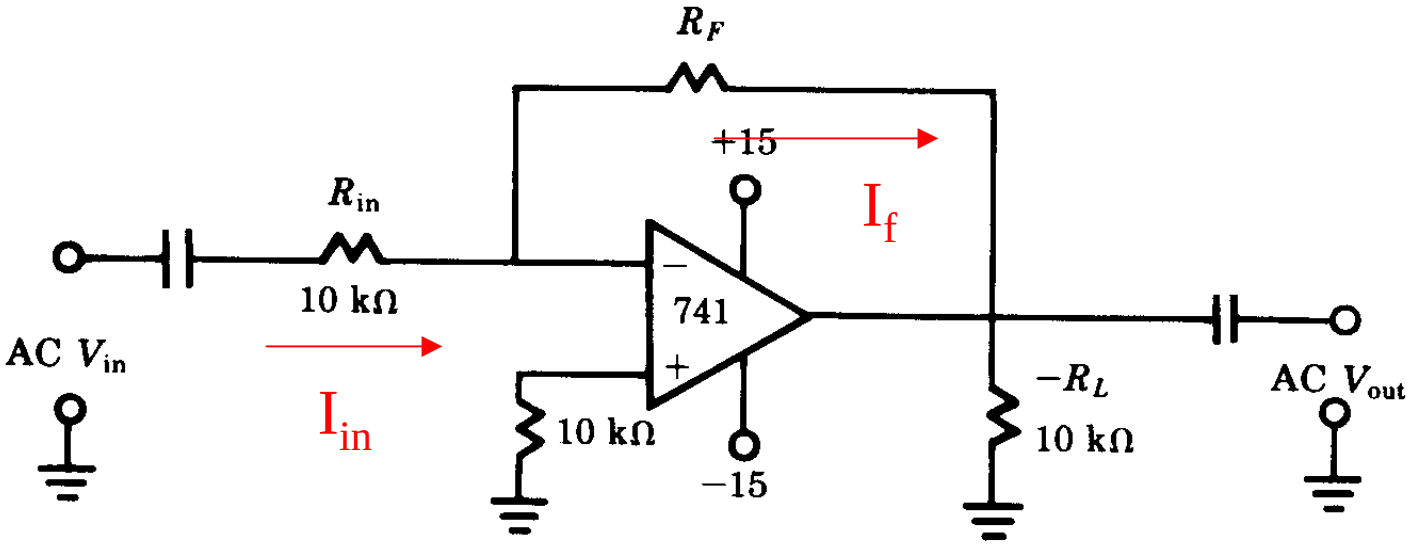
The Operational Amplifier

- Very high input impedance
- Very high “open-loop” gain (G)
- Very low output impedance
- Output can almost swing “rail-to-rail” without clipping and no distortion
- Almost an “ideal” amplifier



- Differential Input
  - $V_{out} = G*(V_+ - V_-)$
- Some have differential outputs
- Fast “slew” rate
  - Maximum rate of change in V_{out}

A “741” Amplifier



- Since “G”, the open circuit gain, is very high

  $V_- \sim V_+$ which is zero (otherwise the output would go to a rail)
- The current going into the V_- input is also zero so $I_{in} = I_f$
- But $I_{in} = V_{in}/R_{in}$ and $I_f = -V_{out}/R_f$ so $V_{in} / R_{in} = -V_{out}/R_f$ so: $V_{in} / V_{out} = \mathbf{A_f = -R_f/R_{in}}$, the amplifier gain with feedback

Inside a 741 Op-Amp

- 20 transistors
- 11 resistors

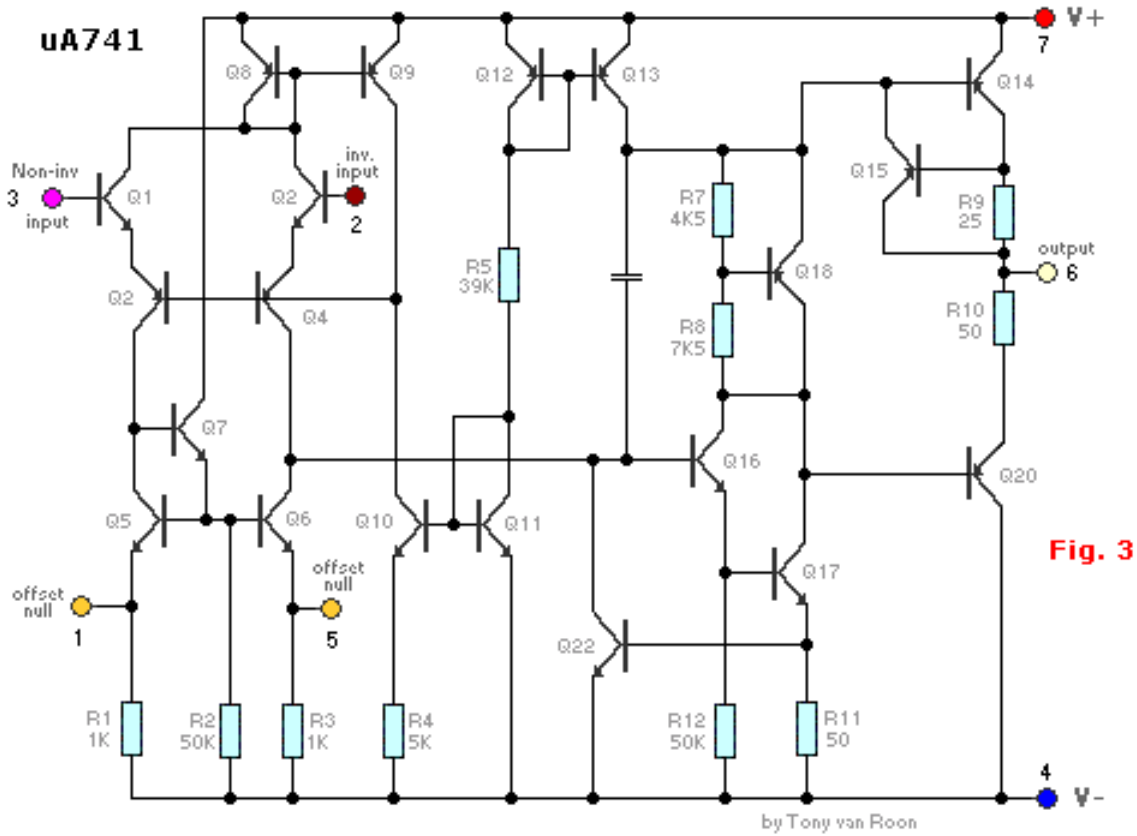


Fig. 3

The real 741

- Not the best Op-Amp
  - Limited speed / gain
  - 20kHz at a gain of 10
- Inexpensive and widely used

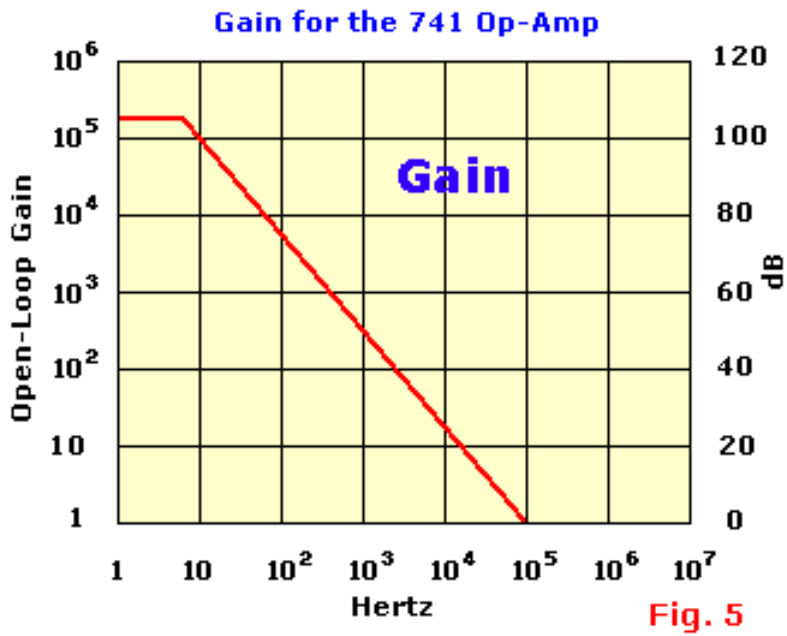


Fig. 5

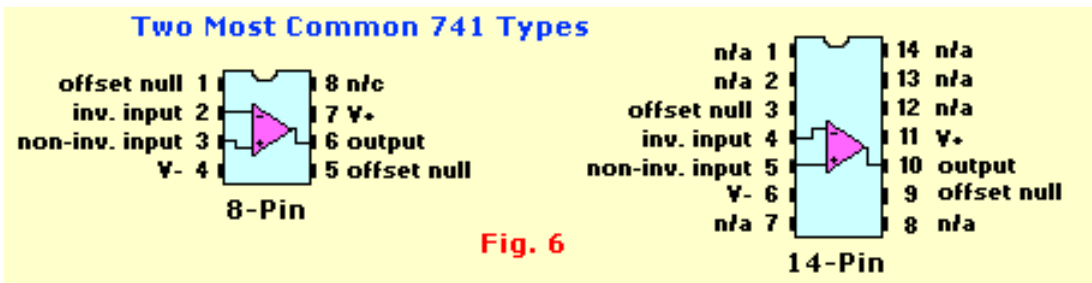


Fig. 6

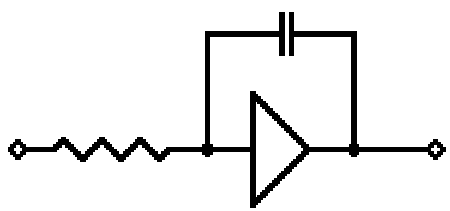
741 Maximum Ratings

- These are the manufacturer's ratings for the 741 IC

Max Ratings	Fig. 2
Supply voltage	±18Volts
Internal Power Dissipation	500mW
Differential Input Voltage	±30Volt
Input voltage	±15Volt
Voltage Offset Null/V-	±0.5Volt
Operating Temperature Range	0° to +70°C
Storage Temperature Range	-65° to +150°C
Lead Temperature, Solder, 60sec.	300°C
Output Short Circuit	Indefinite

Op-Amp Applications

- Comparator: input is compared to a threshold and the output is either at one rail or at the other
- Small signal amplifier (class A)
- Instrumentation amplifier
- Integrator



Op-Amp Summary

- *Gain--infinite (for all practical purposes)*
  - $\mathbf{A_f = -R_f/R_{in}}$ *using the inverting input and feedback*
- *Input impedance--infinite*
- *Output impedance--zero*
  (short circuit protected)
- *Bandwidth--infinite*
  (not really, only in the ideal case)
- *Voltage out--zero*
  (when voltages into each input are equal)

Section 6 Schedule:

Session 6a	01/15	Field Effect Transistors	Kybett pp 70 – 77, pp 201-209
Session 6b	01/20	Transistors as a switch	Kybett pp 78 –107
Session 6c	01/22	SCR's, Triacs and UJTs	Notes
Session 6d	01/27	Class A, B, and C Amplifiers	Notes
Session 6e (no class Monday)	01/29	Q & A	
Session 6e **(Lab - 02/08, Sat.)**	02/05	Operational Amplifiers	Kybett pp 209-215
Session 6f (Quiz 6 due 02/23)	**02/10**	**Review for Quiz 6 (no class 2/17 or 2/19)**	
Session 6g	02/24	Discuss Quiz 6	
Session 6h	02/26	Review for MT3	
MT3	03/01	MT3 Exam	
Session 6i	03/10	Discuss MT3	