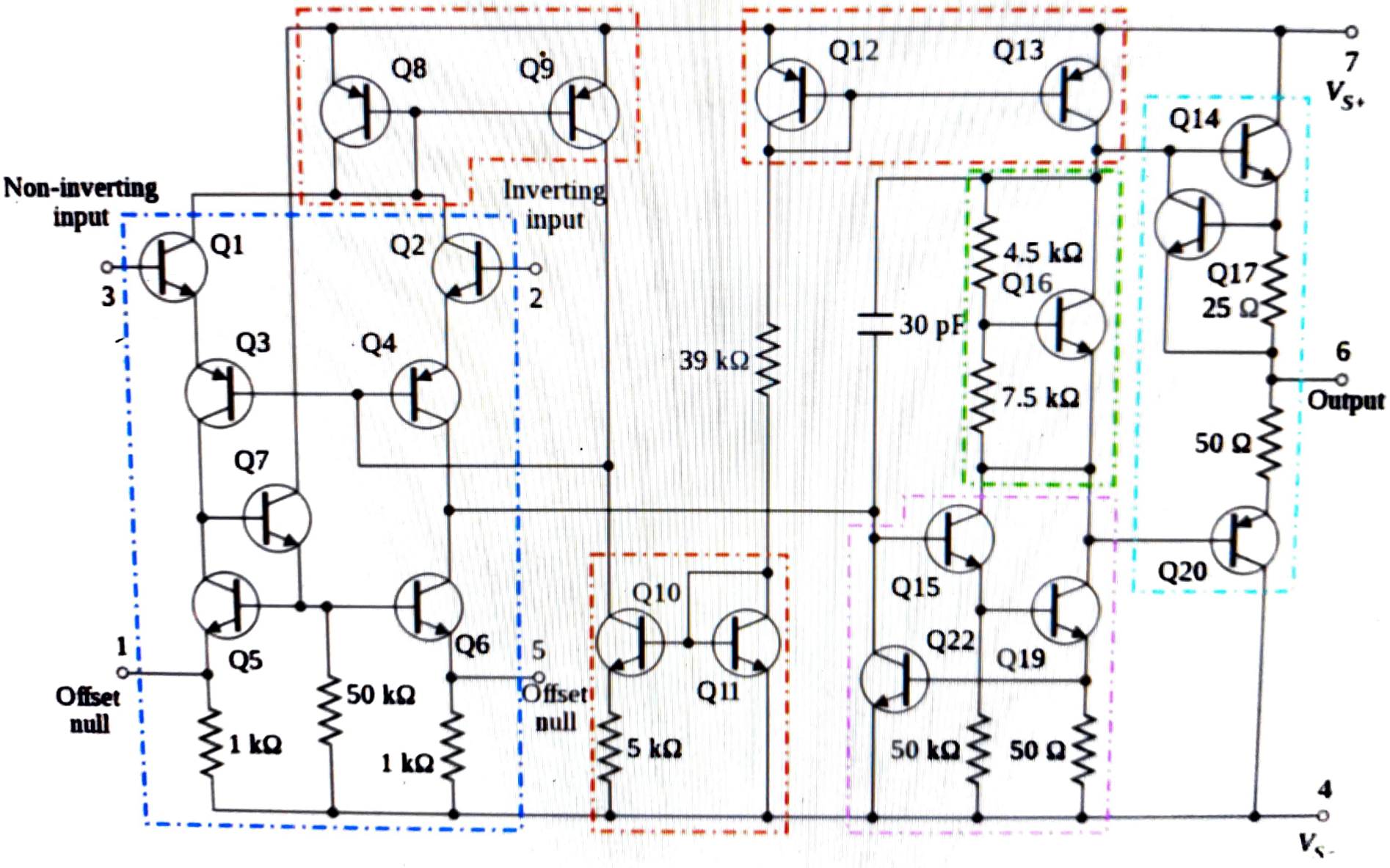
Operational Amplifier

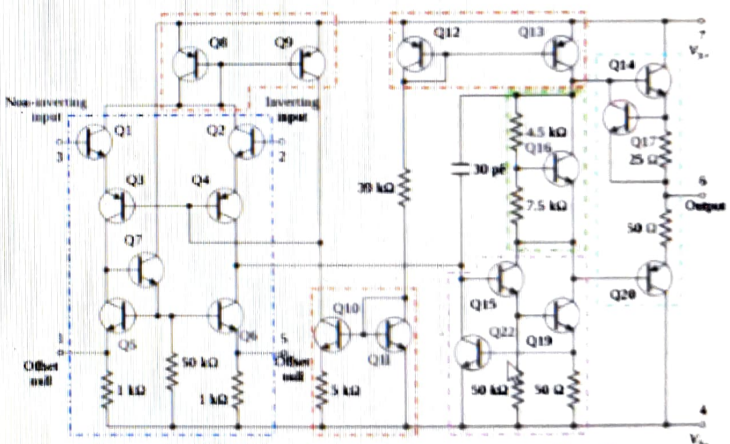
Dr. E. Paul Braineard

Op-amp IC


Non-inverting input
3
Inverting input
2
Offset null
1
Offset null
5
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
Q9
Q10
Q11
Q12
Q13
Q14
Q15
Q16
Q17
Q19
Q20
Q22
1 kΩ
50 kΩ
1 kΩ
39 kΩ
5 kΩ
30 pF
4.5 kΩ
7.5 kΩ
25 Ω
50 Ω
50 kΩ
50 Ω
7
V_{S+}
6
Output
4
V_{S-}

Op-amp

- Direct coupled very high gain voltage amplifier
- Integrated circuit
- Differential input and single output



Direct coupled: the output of one stage of amplifier is connected directly to the input of next stage without any coupling capacitor

Ideal characteristics of op-amp

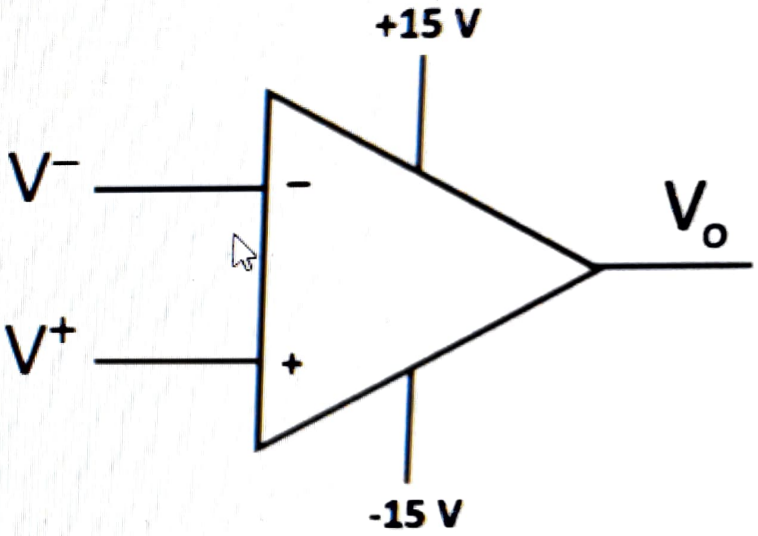
- Open loop gain infinite,

  $A_{OL} = \infty$
- Input impedance infinite,

  $R_i = \infty$
- Output impedance low,

  $R_o = 0$
- Bandwidth infinite,

  $BW = \infty$
- Zero offset, ie, $V_o = 0$ when $V^+ = V^- = 0$



Op-amp circuit symbol

Operational characteristics of op-amp

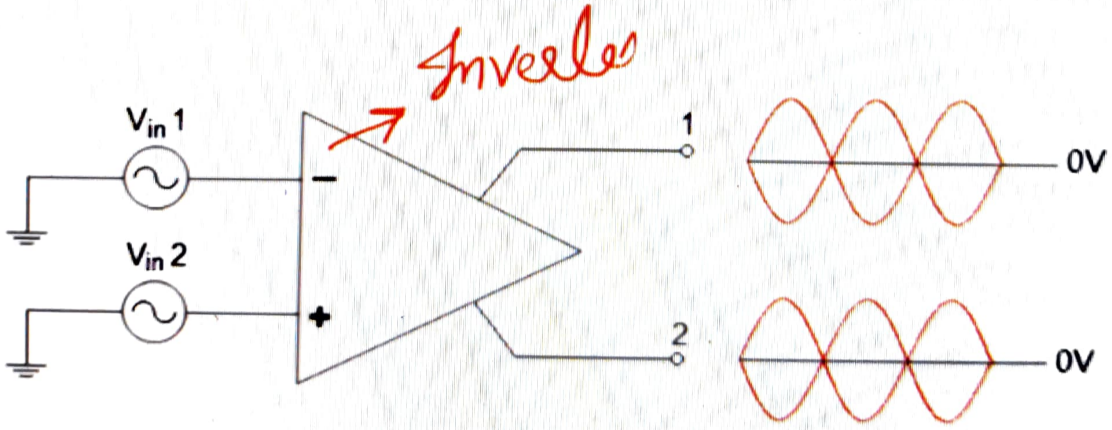
- Practical op-amp
  - Draws current ✓ (negligible)
  - Inputs respond differently to currents and voltages due to mismatches in transistors
  - Operating point shifts with temperature
- Add error to the DC output voltage

DC non-ideal characteristics of op-amp

- Input bias current
- Input offset current
- Input offset voltage
- Thermal drift

Differential and Common-Mode Signals

- most important aspect of the operation of a differential amplifier
- where two signal voltages of the same phase, frequency, and amplitude are applied to the two inputs.
- When the input signals are applied to both inputs, then the outputs are superimposed and they cancel, resulting in a zero output voltage.
- This action is called **Common-Mode Rejection**



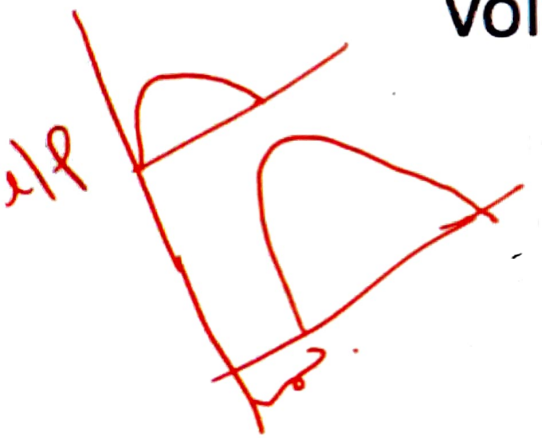
CMRR

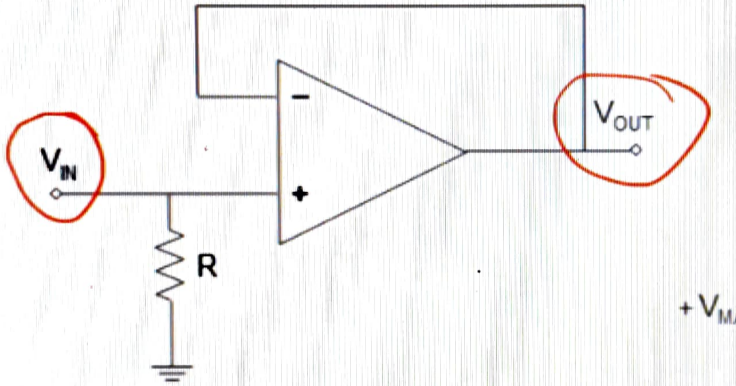
- Common mode rejection ratio
- The measure of an amplifier's ability to reject common-mode signals

$$CMMR = \frac{A_{V(d)}}{A_{CM}}$$

Slew Rate

- The maximum rate of change of the output voltage in response to a step input voltage

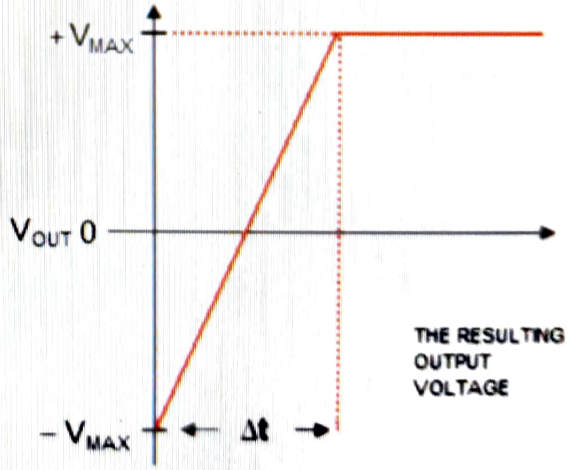




$$SLEWRATE = \frac{\Delta V_{OUT}}{\Delta t}$$

where $\Delta V_{OUT} = +V_{MAX} - (-V_{MAX})$

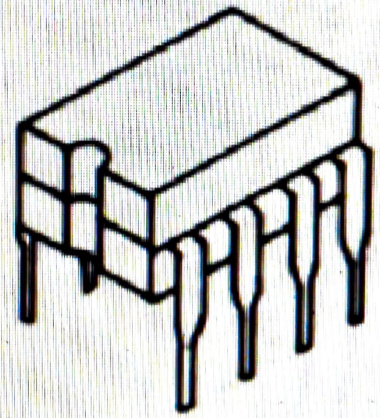
units (V/μs)



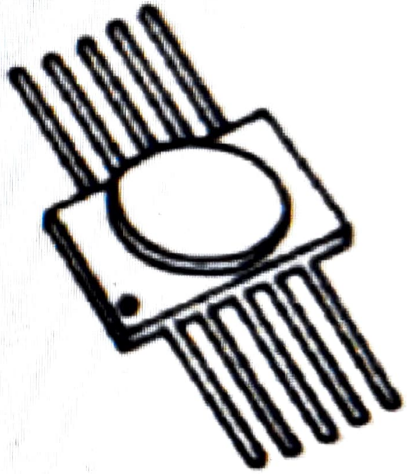
Packages of IC741

Metal can (TO) package, Dual-in-line package, Flat package

TO-5 style package with straight leads

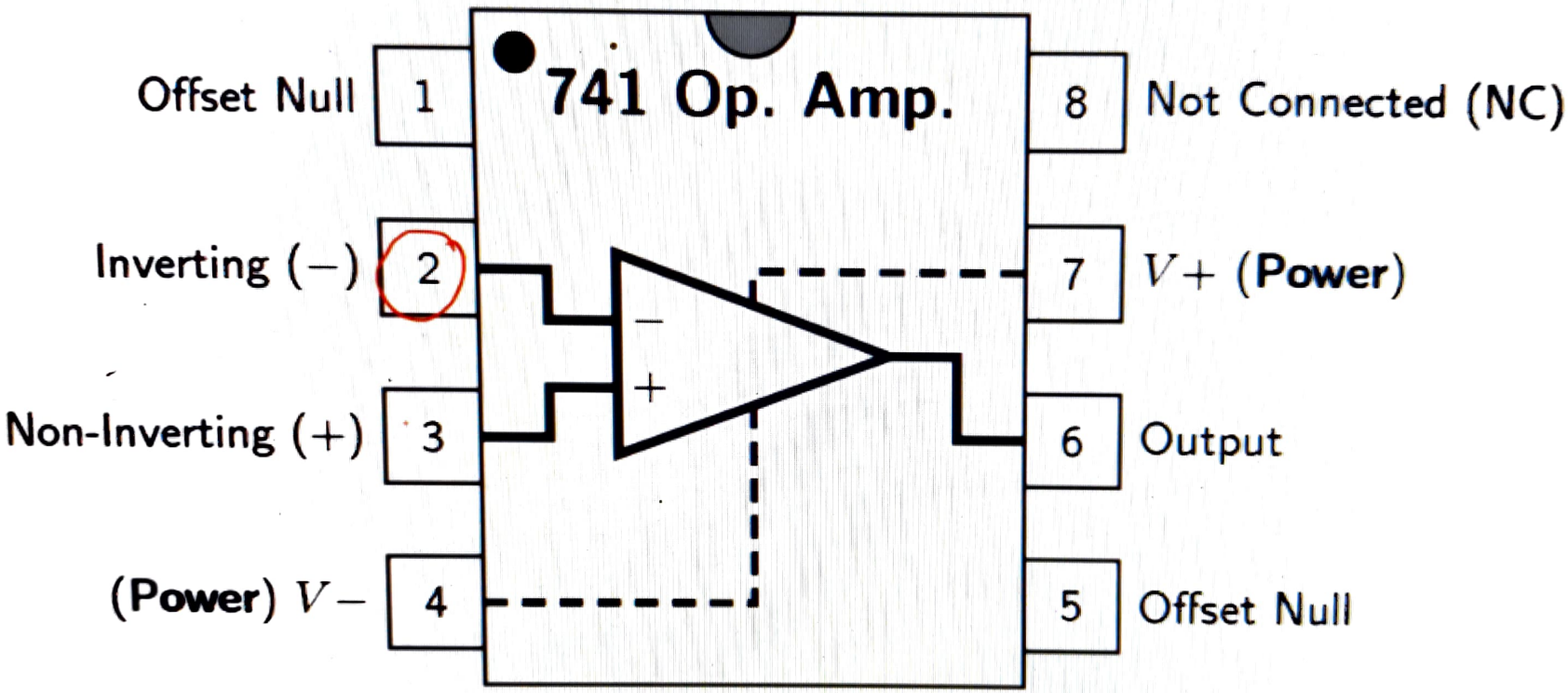


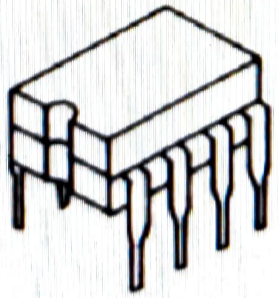
Ceramic flat package



IC packages of μA741

Pin diagram of 741 op-amp





Dual-in-line package

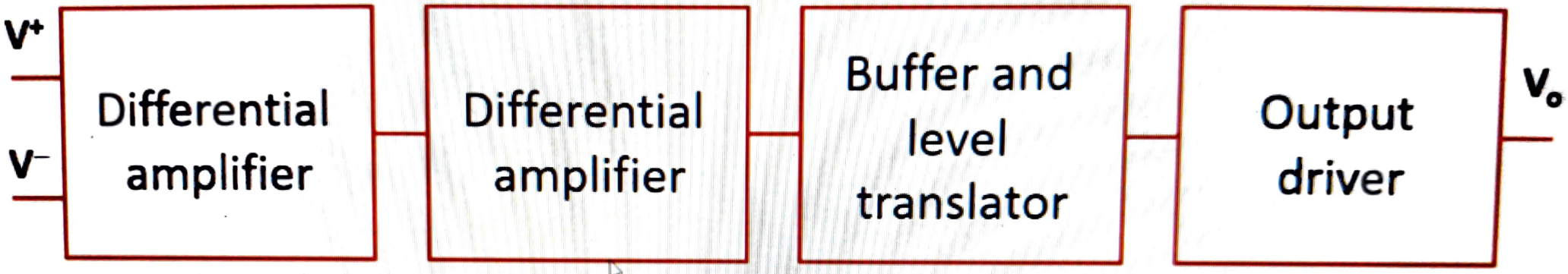
Op-amp manufacturers

Manufacturer	Product number
Fairchild (Original)	μA741
National semiconductor	LM741
Motorola	MC1741
RCA	CA3741
Texas instruments	SN52741
Signetics	N5741

Op-amp classes

Class	Application	
741	Military grade op-amp (Operating temp. range -55 °C to 125 °C)	
741C	Commercial grade op-amp (Operating temp. range 0 °C to 70/75 °C)	
741A	Improved version of 741	Better electrical specifications
741E	Improved version of 741 C	
741S	Military grade op-amp with higher slew-rate	
741SC	Commercial grade op-amp with higher slew-rate	

Block diagram of op-amp



- First two stages, cascaded differential amplifier
  - High gain, high resistance