RANGKAIAN ELEKTRONIKA II

Penguat Operasional

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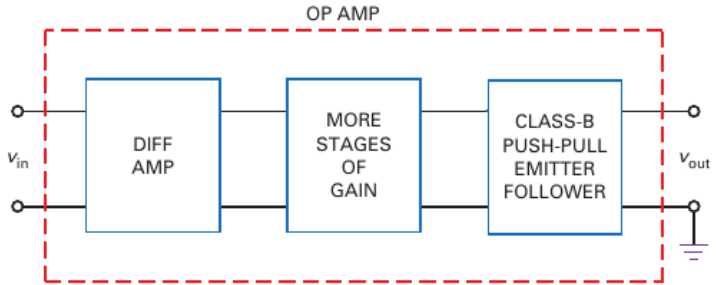
Bahan Kajian

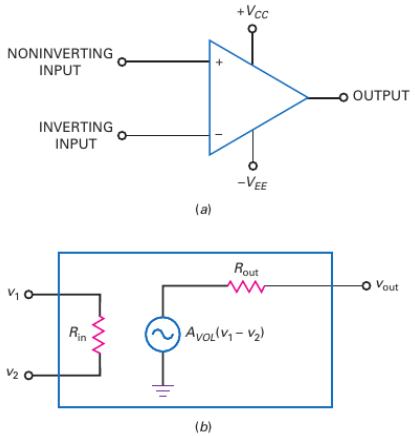
1. Pengantar
2. Op Amp 741
3. Inverting Amplifier
4. Non-inverting Amplifier
5. Aplikasi Op-Amp

Pengantar



Gambar. 1: Blok diagram sebuah op amp

Pengantar



Gambar. 2: (a) Simbol dari op amp dan (b) rangkaian ekivalen dari op amp

Pengantar

Summary Table 16-1	Typical Op-Amp Characteristics			
Quantity	**Symbol**	**Ideal**	**LM741C**	**LF157A**
Open-loop voltage gain	A_{VOL}	Infinite	100,000	200,000
Unity-gain frequency	f_{unity}	Infinite	1 MHz	20 MHz
Input resistance	R_{in}	Infinite	2 MΩ	10^{12} Ω
Output resistance	R_{out}	Zero	75 Ω	100 Ω
Input bias current	$I_{in(bias)}$	Zero	80 nA	30 pA
Input offset current	$I_{in(off)}$	Zero	20 nA	3 pA
Input offset voltage	$V_{in(off)}$	Zero	2 mV	1 mV
Common-mode rejection ratio	CMRR	Infinite	90 dB	100 dB

Gambar. 3: Perbandingan karakteristik op amp ideal dan op amp standar

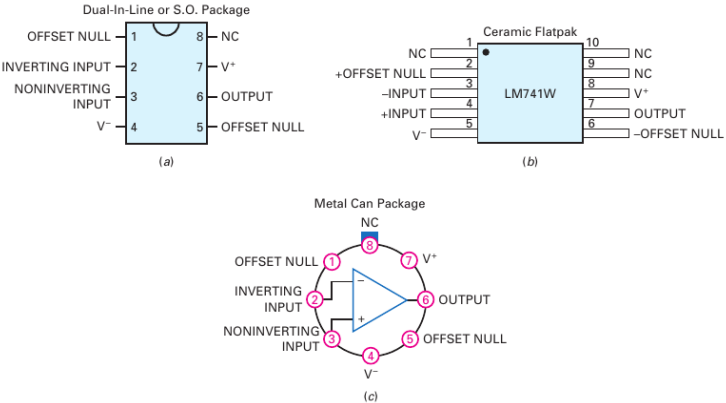
Op Amp 741

- Monolitic amp μA709 tahun 1965 oleh Fairchild Semiconductor
- μA709 memiliki kekurangan $\rightarrow$ dibuatlah μA741
- Banyak manufaktur yang membuat μA741:
  - ON Semiconductor: MC1741
  - Texas Instruments: LM741
  - Analog Devices: AD741.
- Istilah umumnya op amp 741

Standar Industri

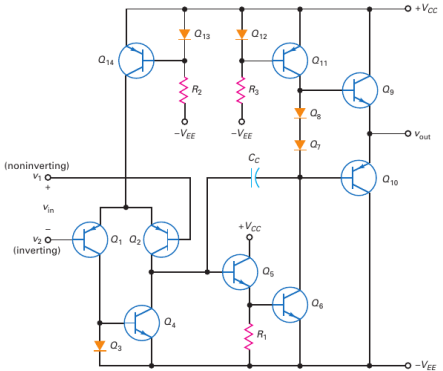
- Beberapa versi: 741, 741A, 741C, 741E, dan 741N
- Bergantung pada karakteristiknya (voltage gain, temp. range, noise level, dll)
- 741C (C = *Commercial grade*) $\rightarrow$ sedikit lebih murah dan paling banyak digunakan
- $A_{VOL} = 100000$, $z_{in} = 2$ MΩ, $z_o ut = 75$ Ω

Standar Industri



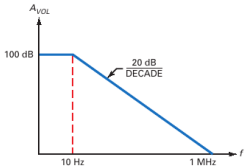
Gambar. 4: Op amp 741 pinouts (a) dual-in-line, (b) ceramic flatpak, (c) metal can

Rangkaian Ekivalen dari Op Amp 741



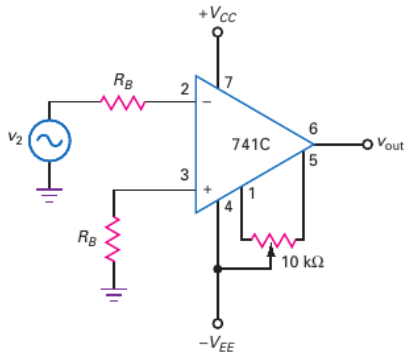
Gambar. 5: Rangkaian ekivalen dari op amp 741

- Input diff amp
- Final Stage
- Active Loading
- Frequency Compensation
  $C_{in(M)} = (A_v + 1)C_c$



Gambar. 6: Bode plot A_{VOL} 741C ideal

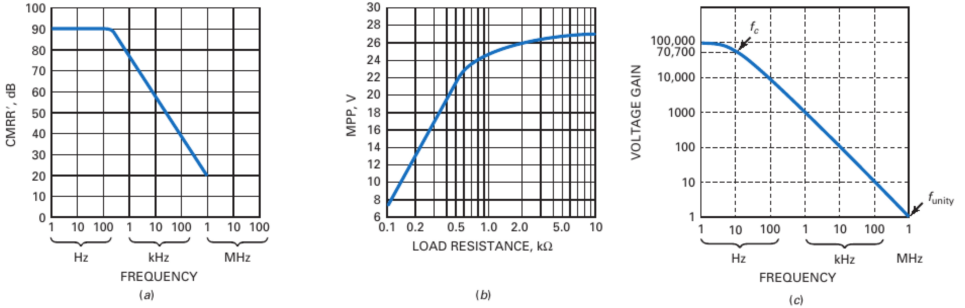
Bias & Offset



Gambar. 7: Penggunaan compensation dan nulling 741C

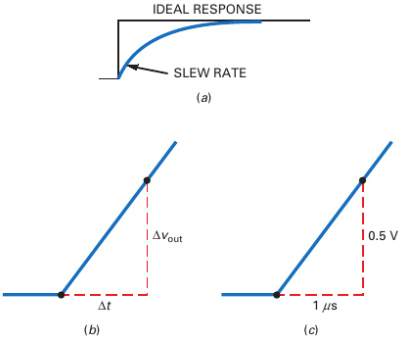
- Tidak ada input signal → input bias dan offset → error output
- Error output berkurang ← base resistor yang sama → hanya menghilangkan arus bias tapi tidak arus offset dan tegangan offset
- Solusi: menggunakan rangkaian nulling di datasheet

CMRR, MPP, dan A_{VOL}



Gambar. 8: Grafik (a) Common-Mode Rejection Ratio (CMRR), (b) Maximum Peak-to-Peak Output (MPP), dan (c) Open-Loop Voltage Gain A_{VOL} dari 741C

Slew Rate



Gambar. 9: (a) Respon ideal dan aktual terhadap tegangan step input, (b) ilustrasi definisi slew rate, (c) $S_R = 0.5\ \text{V}/\mu\text{s}$

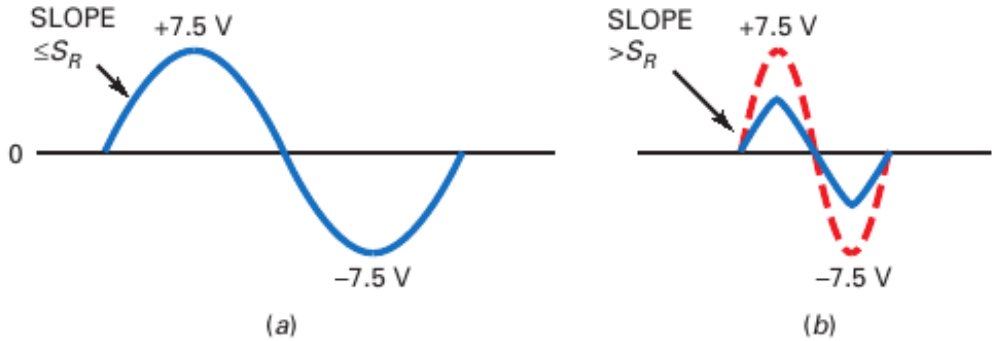
- Persamaan slew rate, S_R

$$S_R = \frac{\Delta v_{out}}{\Delta t} \qquad (1)$$

- Exponential wave meningkat 0.5 V selama 1 mikrodetik pertama:

$$\begin{aligned} S_R &= \frac{\Delta v_{out}}{\Delta t} \\ &= \frac{0.5\ \text{V}}{1\ \mu\text{s}} \\ &= 0.5\ \text{V}/\mu\text{s} \end{aligned}$$

Slew Rate



Gambar. 10: (a) Initial slope dari gelombang sinus, (b) distorsi terjadi jika initial slope melebihi slew rate

Slew Rate

- Sinyal dan frekuensinya sangat kecil $\rightarrow$ slew rate bukan masalah
- Sinyal dan frekuensinya sangat besar $\rightarrow$ slew rate akan mendistorsi sinyal ouput

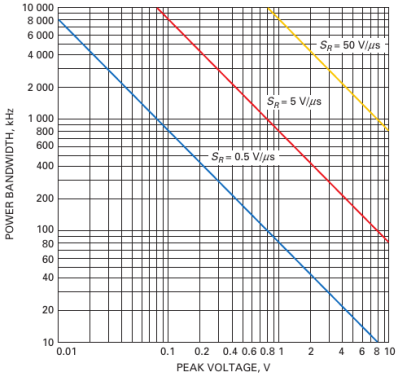
$$S_S = 2\pi f V_p$$

- S_s: initial slope dari gelombang sinus, f: frekuensi, V_p: nilai peak

$$\begin{aligned} S_S &\leq S_R \\ 2\pi f V_p &\leq S_R \\ f &\leq \frac{S_R}{2\pi V_p} \end{aligned}$$

$$f_{max} = \frac{S_R}{2\pi V_p} \tag{2}$$

Slew Rate



Gambar. 11: Grafik power bandwidth vs. peak voltage

- f_{max}: power bandwidth atau large-signal bandwidth

Inverting Amplifier

- Item

Non-inverting Amplifier

- Item

Aplikasi Op-Amp

- Item

TERIMA KASIH