5374, Operational Amplifier Laboratory

EXP. 8, GAIN-BANDWIDTH PRODUCT

Eight-pin IC, LM741CN
Op Amp Amplifier Basics

There are two basic forms in which an Op Amp (Operational Amplifier) can be used as an amplifier:

- Inverting configuration
- Non-inverting configuration
741 DIP Pinout Diagram

8 Pin DIP or DIL (Dual In Line Package)
Frequency Response of 741 Op Amp

- No amplifier has infinite frequency response: there is a limit to the frequency any amp will handle.
- We have some control over frequency response of some op amps through negative feedback.
• The 741 controls the frequency response itself by means of a capacitor by a capacitor which is incorporated in the IC.

• This is called an internally compensated op amp.
Figure 25 illustrates the frequency response of a type 741 op amp.
You will see the frequency starts to drop off at about 1M Hz.
We can increase the frequency response considerably by making some tradeoffs in circuit design.
Open-loop Response of 741 Op Amp

Open-Loop Voltage Gain as a Function of Frequency

- $V_S = \pm 15\text{V}$
- $T_A = 25\degree\text{C}$

- $V_S =$ Voltage Source or Supply Voltage
- $T_A =$ Ambient Temperature

Graph showing the open-loop voltage gain as a function of frequency.
Beginning Oscilloscope Settings after Calibration

- Remember to calibrate your oscilloscope after turning it on.
- After initial presets, change setting to read one complete cycle.
- Preset your oscilloscope (controls and switches) as indicated for Experiment 7 before using.
- Vertical mode switch to Dual
  - You want to view both input & output signals at the same time. Set the AC/GND/DC selector switch to AC.
- Set the Time per Division selector Switch to 2mS.
- Set channel 1 Volts per Division selector switch to .2 Volts.
- Set channel 2 Volts per Division selector switch to 2 Volts.
Inverting Op Amp Schematic
Practical Considerations for the 741 Inverting Op Amp

- The input signal is applied to the inverting input
- Because of this, the output signal is inverted in phase with relation to the input signal or 180° out of phase
• Non-inverting input is grounded
• One assumption is the input error voltage is zero
  - The feedback keeps inverting the input at a virtual ground
• The current flow in the input lead is assumed to be zero.
Hence the current flowing through $R_1$ is the current flowing through $R_F$.

- The gain is independent of the Op Amp parameters.
- Gain is a function of the feedback and gain resistors.
- $R_2$ is often used in an inverting amplifier to compensate for effects of input bias current.
  - In many applications, $R_2$ is equal to the parallel equivalent resistance of $R_F$ and $R_1$.
  - $R_2$’s value only becomes critical if $R_F$ has a high value.
The common mode voltage should be within +/-12V for +/-15V supply.
The output impedance is about 75 ohms.
The voltage gain rolls off 6dB per octave starting at 100kHz.
Maximum output Current: 20mA
Practical Considerations for the 741 Operational Amplifier

- The input bias current is about 80 nA
- The input offset current is about 10 nA
- The input impedance is about 2 Meg Ohms
There is a finite input offset which must be zeroed by a resistor between pins 1 and 5. The input offset is typically 2mV to <6mV.

The slew rate is .3V to .5V/microseconds which is the max rate in which $E_{OUT}$ of the op amp can change.

There is some temperature dependence
• The voltage between the two input terminals of a normally operating Op Amp is always zero volts.

• The maximum output-voltage swing of an Op Amp should ideally be equal to the value of the applied voltage.

  ○ The actual maximum output swing of the 741 Op Amp is actually a little less than the theoretical maximum. (Applied Voltage)
The op amp will no longer operate linearly if you try to exceed this value.

The accuracy of the circuits to meet the calculated values is dependent on the actual values of the components used. (Values with their tolerances)
• Remember resistors have a tolerance.
  ○ The calculated gain of the amplifier will very likely be different than the measured gain.

• This is also true for capacitors and pretty much any component manufactured by man.
Inverting Amp Voltage Gain

- $A_V = -\frac{R_F}{R_1}$

  Remember: The minus sign indicates the phase reversal characteristics of the circuit.

- $A_V = -\frac{E_{OUT}}{E_{IN}}$ or $-\frac{V_{OUT}}{V_{IN}}$
Inverting Op Amp Schematic

- To Trainer Sine Terminal
- To Trainer Positive Supply (+15V)
- To Trainer Negative Supply (-15V)
- E_{out}
- Trainer Ground
- R_3 = 100kΩ
- R_4 = 1kΩ
- R_1 = 1kΩ
- R_2
- R_F = 100kΩ
5374 Exp. 8 circuit Constructed
Gain-Bandwidth Product of an Inverting Operational Amplifier

- Use the following formula to determine how much gain is available at a particular band-width.

$$GBD = A_V \times BW$$

Example: $10^6 = A_V \times 10^4$

$10^6/10^4 = A_V$

$10^2 = A_V$
GBD = $A_v$ BW

Example: $10^6 = 50$BW

$10^6/50 = BW$

20kHz = BW
Additional Discussion

- Remember: the theoretical and measured Voltage Gains can vary as much as 20% due to the resistor tolerances.
- It is not unusual to see gains from 81.8 to approximately 111 with the values of resistances used.
QUESTIONS?
Resources


Developed and Produced by the Instructors in the CIE Instruction Department.

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