EEE 3571 Electronic Engineering I

Lecture 9: Operational Amplifiers- Non-Inverting Ckts

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References

Our main reference text books in this course are

[1] Neil S., Electronics: A Systems Approach, 4th edition, 2009, Pearson Education Limited, ISBN 978-0-273-71918-2.

[2] Boylestad R. L., Nashelsky L., Electronic Devices and Circuit Theory, 11th Ed, 2013, Prentice-Hall, ISBN 978-0-13-262226-4.

[3] Smith R. J., Dorf R. C., Circuits Devices and Systems, 5th Ed., 2004, John Wiley, ISBN ISBN 9971-51-172-X.

However, feel free to use pretty much any additional text which you might find relevant to our course.

9.3 Noninverting Circuit Applications

- In a noninverting circuit, shown in Fig. 1, the input signal is applied to the noniverting + terminal, and a fraction of the output signal is fed back to the inverting – terminal.
- Here R_1 and R_F constitute a voltage divider across the output voltage. For an ideal op amp with $v_i = 0$,

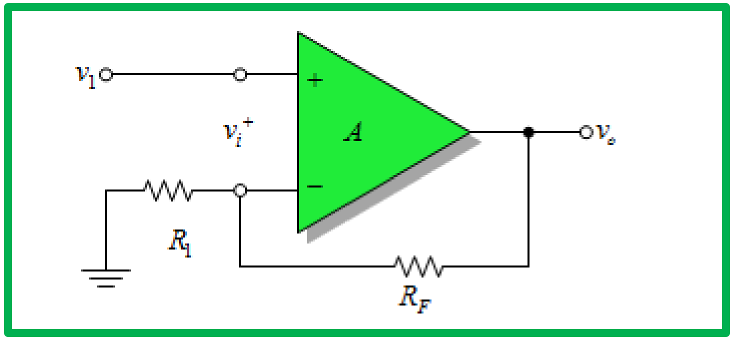


Fig. 1: The noniverting amplifier circuit.

$$v_1 - \frac{R_1}{R_1 + R_F} v_o = v_i = 0 \qquad [1]$$

Thus,

$$A_F = \frac{v_o}{v_i} = \frac{R_1 + R_F}{R_1} \qquad [2]$$

- This basic noninverting amplifier has two distinctive features.
- First, output signals are in phase with those at the input. Second, the input resistance is very high, approaching infinity in practical terms, and the output resistance is very low.

Noninverting Circuit Applications

- This implies that noninverting amplifiers do not "load" their sources and, in turn, they are not affected by their loads.

Voltage Follower

- A useful special case of the noninverting circuit is shown in Fig. 2. Here $R_F = 0$ and $R_1 = \infty$ (open circuit). From Eq. [3], the circuit gain is now

$$A_F = \frac{v_o}{v_i} \cong \frac{R_1 + R_F}{R_1} = 1 \quad [3]$$

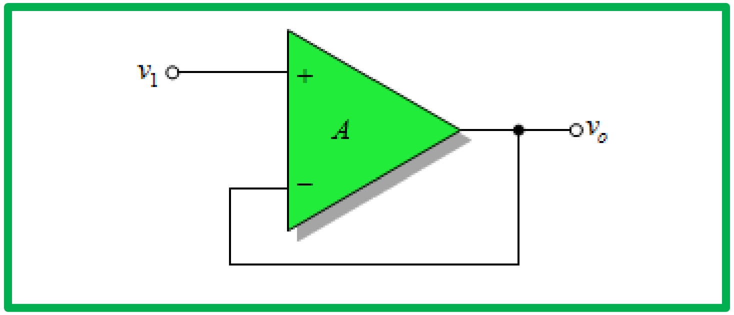


Fig. 2: The voltage-follower circuit.

- The output voltage is just equal to the input voltage and this is the voltage follower.

- It is known as a voltage follower because the potential at the v_o terminal "follows" the potential at the v_1 terminal.

[Example 1] Noninverting Circuit Applications Cont'd

- Clearly, the circuit in question is a voltage follower with unity gain. With feedback, the input resistance is

$$R_{iF} \cong \frac{v_s}{i_i} \cong \frac{10}{1.01 \times 10^{-9}} \cong 10^{10}\ \Omega$$

a very high value.

Unity-Gain Buffer

- Example 1 demonstrates that the gain of a voltage follower is almost exactly 1. Its usefulness lies in its ability to isolate a high-resistance source from a low-resistance load. To achieve this, the isolating network ought to have a very high input resistance and a very low output resistance.
- In general, such a network is known as a buffer. We cannot use the ideal op amp model to derive the general input and output characteristics of such a unity-gain buffer since they depend on the non-ideal properties of the op amp.

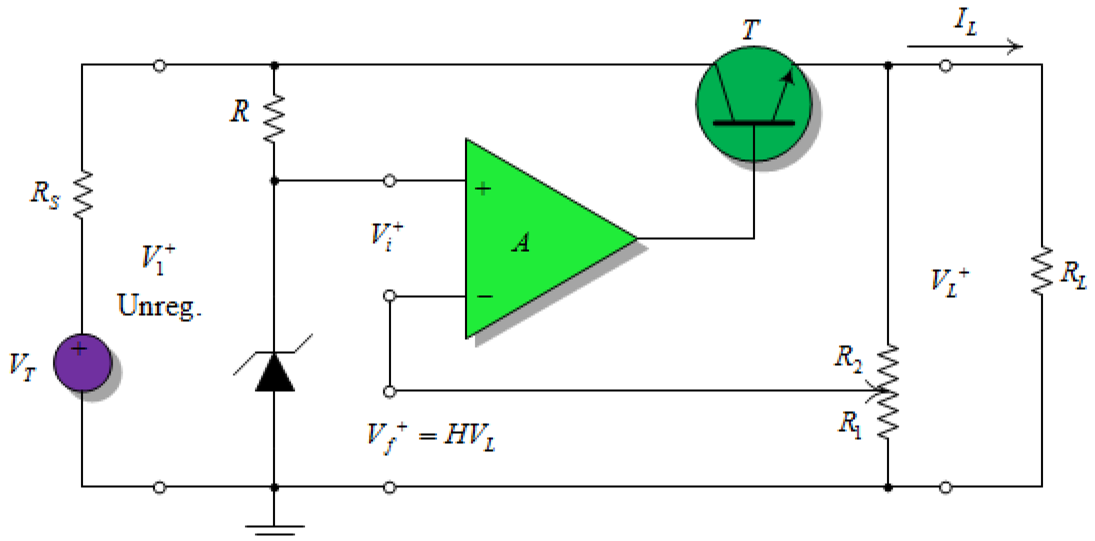
Noninverting Circuit Applications

Voltage Regulator

- The simple Zener diode voltage regulator is meant to alleviate the effects of supply voltage fluctuation V_1 and load current variation I_L on the load voltage V_L .
- By using a high-gain amplifier and negative feedback, we can obtain much better regulation.
- In a practical power supply, a transformer provides an ac voltage at the proper level, a diode rectifier provides unidirectional current, and a capacitor filter develops an unregulated dc voltage. Thus, a regulator is added to alleviate voltage fluctuations.

Voltage Regulator

- In Fig. 6a, transistor *T* acts as a variable voltage dropping element, in series, with the load resistance R_L so that $V_{CE} = V_1 - V_L$.
- The op-amp such as 741 is used as a sensitive control of the pass element *T*. The Zener diode provides a constant reference voltage $V_Z = v_p$.



(a) Op amp regulator.

Noninverting Circuit Applications

- The variable voltage divider R_1-R_2 takes a fraction $H = R_1/(R_1+R_2)$ of the load voltage V_L and feeds it back to the inverting terminal so that $v_n = V_f = HV_L$.

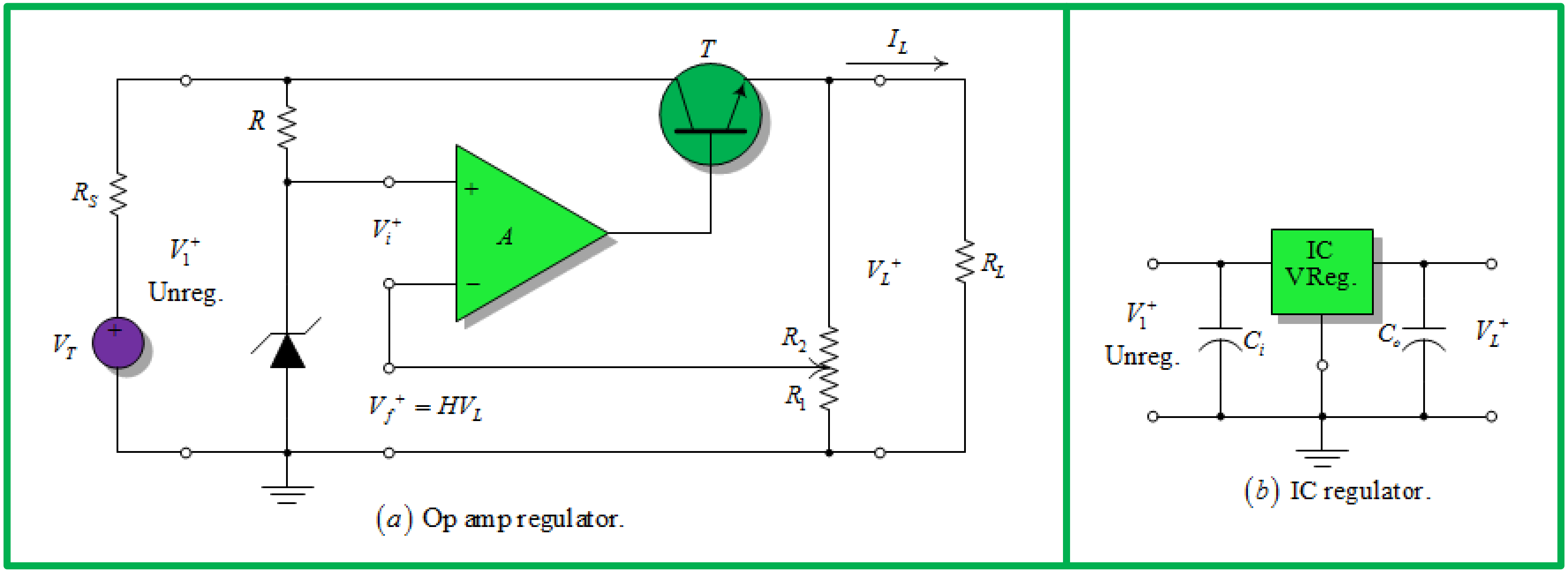


Fig. 6: Voltage regulators with feedback.

Noninverting Circuit Applications

- In effect, we compare V_f to the reference voltage V_Z ; any difference is amplified and used to control the base current to the transistor *T*.
- If for any reason the load voltage tends to drop, V_f decreases slightly, $V_i = v_p - v_n$ increases significantly, and the base current to *T* increases, increasing emitter current and stabilizing V_L .
- The pass transistor must be able to dissipate the power $P_D = V_{CE} I_L$; an adequate "heat sink" is required.
- The variation of V_{BE} and V_Z with temperature is a principal limitation on the voltage stability of the ckt in Fig. 6a. Furthermore, the ckt provides no high-current protection; as a short ckt may destroy *T*.
- To alleviate these difficulties, the sophisticated circuitry in IC form is used, see Fig. 6b. Capacitor C_i and C_o improve the operation by reducing the effect of transformer inductance at the input and minimizing the effect of sudden changes in load at the output.

End of Lecture 2

Thank you for your attention!