20-1 Inverting-Amplifier Circuits

In this chapter and succeeding chapters, we will be discussing many different types of op-amp circuits. Instead of providing a summary page showing all of the circuits, small summary boxes will be given containing the important formulas for circuit understanding. Also, where needed, the feedback resistor, R_f, will be labeled as R, R_2, or other designations.

The inverting amplifier is one of the most basic circuits. Chapters 18 and 19 discussed the prototype for this amplifier. One advantage of this amplifier is that its voltage gain equals the ratio of the feedback resistance to the input resistance. Let us look at a few applications.

High-Impedance Probe

Figure 20-1 shows a high-impedance probe that can be used with a digital multimeter. Because of the virtual ground in the first stage, the probe has an input impedance of 100 MΩ at low frequencies. The first stage is an inverting amplifier with a voltage gain of 0.1. The second stage is an inverting amplifier with a voltage gain of either 1 or 10.

The circuit of Fig. 20-1 gives you the basic idea of the 10:1 probe. It has a very high input impedance, and an overall voltage gain of either 0.1 or 1. In the X10 position of the switch, the output signal is attenuated by a factor of 10. In the X1 position, there is no attenuation of the output signal. The basic circuit shown here can be improved by adding more components to increase the bandwidth.

AC-Coupled Amplifier

In some applications, you do not need a response that extends down to zero frequency because only ac signals drive the input. Figure 20-2 shows an ac-coupled amplifier and its equations. The voltage gain is shown as:

$$A_v = \frac{-R_f}{R_1}$$

For the values given in Fig. 20-2, the closed-loop voltage gain is:

$$A_v = \frac{-100\text{ k}\Omega}{10\text{ k}\Omega} = -10$$

Figure 20-1 High-impedance probe.

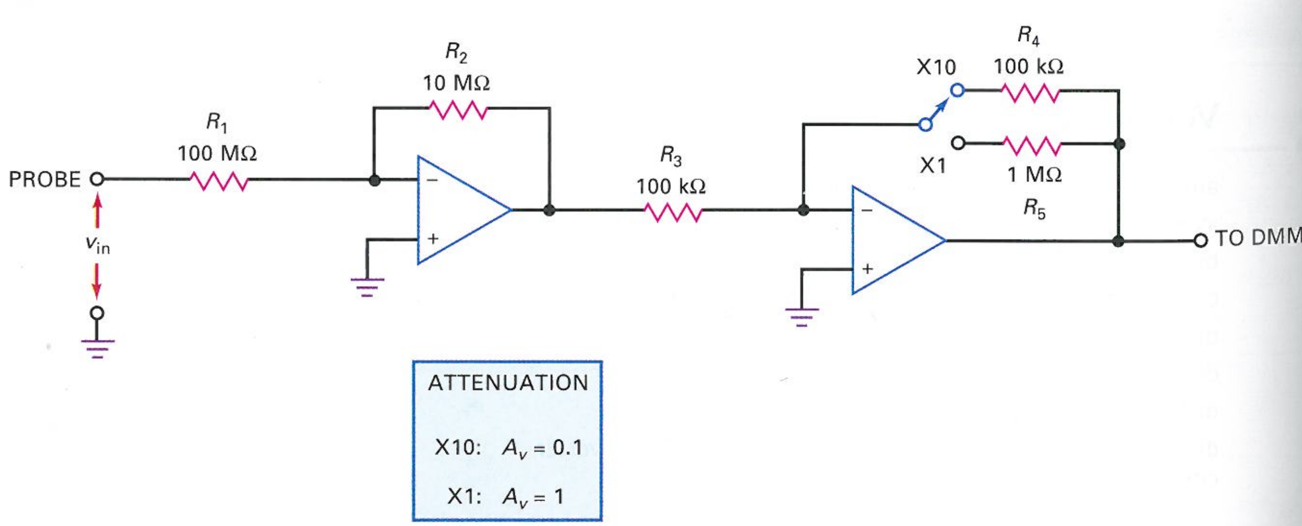
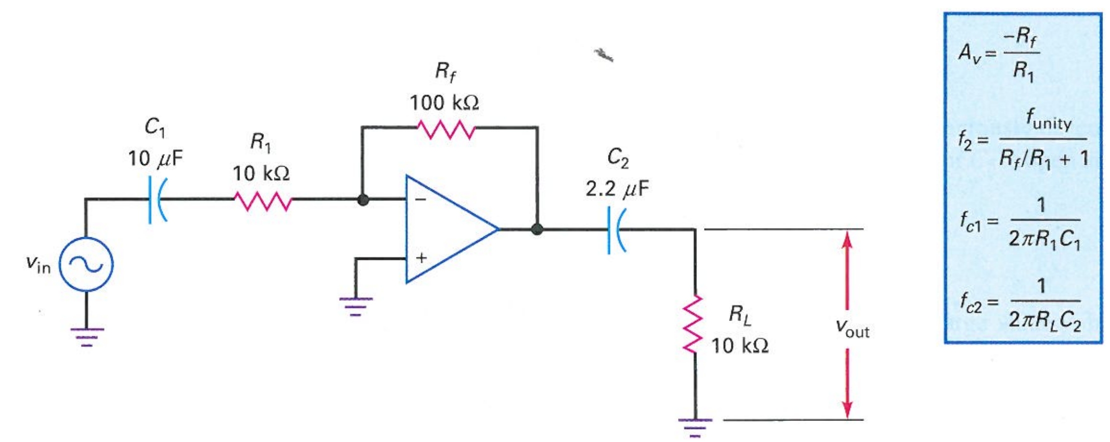


Figure 20-2 AC-coupled inverting amplifier.



If f_{unity} is 1 MHz, the bandwidth is:

$$f_{2(CL)} = \frac{1\text{ MHz}}{10 + 1} = 90.9\text{ kHz}$$

The input coupling capacitor C_1 and the input resistor R_1 produce one of the lower cutoff frequencies f_{c1}. For the values shown:

$$f_{c1} = \frac{1}{2\pi(10\text{ k}\Omega)(10\ \mu\text{F})} = 1.59\text{ Hz}$$

Similarly, the output coupling capacitor C_2 and the load resistance R_L produce the cutoff frequency f_{c2}:

$$f_{c2} = \frac{1}{2\pi(10\text{ k}\Omega)(2.2\ \mu\text{F})} = 7.23\text{ Hz}$$

Adjustable-Bandwidth Circuit

Sometimes we would like to change the closed-loop bandwidth of an inverting voltage amplifier without changing the closed-loop voltage gain. Figure 20-3 shows one way to do it. When R is varied, the bandwidth will change but the voltage gain will remain constant.

Figure 20-3 Adjustable bandwidth circuit.