EXPERIMENT

29

Active Filter Circuits

OBJECTIVE

To calculate and measure the critical frequencies and to measure AC voltages as a function of frequency of various types of active filter circuits.

EQUIPMENT REQUIRED

Instruments

Oscilloscope
DMM
Function generator
DC power supply

Components

Resistors

(5) 10-kΩ
(1) 100-kΩ

Capacitors

(2) 0.001-μF

Transistors and ICs

(1) 301 IC, or equivalent

EQUIPMENT ISSUED

Item	Laboratory serial no.
DC power supply	
Function generator	
Oscilloscope	
DMM	

RÉSUMÉ OF THEORY

Op-amps can be used to build active filter circuits for use as low-pass, high-pass, or band-pass filter operation. Filter operation provides the output of the filter dropoff as a function of frequency to 0.707 of the starting value at the cutoff frequency. This is a drop of 3 dB. The rate of amplitude decrease is at 6-dB per octave (half or twice frequency), which is the same as 20-dB per decade (ten-fold larger or smaller frequency).

Low-Pass Filter

A low-pass active filter passes frequencies below the filter cutoff frequency. The circuit of Fig. 29.1 shows the connection of an op-amp unit as a low-pass filter, the low-cutoff frequency determined by

$$f_L = \frac{1}{2\pi R_1 C_1} \text{ Hz} \tag{29.1}$$

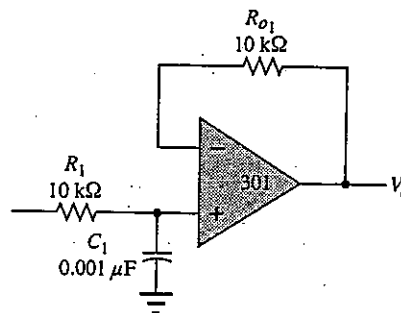The output drops off at 6 dB/octave or 20 dB/ decade above the cutoff frequency.

Figure 29-1

High-Pass Filter

A high-pass filter, as shown in Fig. 29.2, maintains the output amplitude at frequencies above a high cutoff frequency determined by

$$f_H = \frac{1}{2\pi R_2 C_2} \text{ Hz} \tag{29.2}$$

The output drops off at 6 dB/octave or 20 dB/decade below the cutoff frequency.
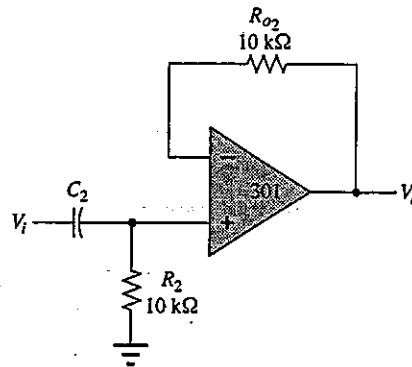
Figure 29-2

Band-Pass Filter

A band-pass filter circuit, as shown in Fig. 29.3, passes the input signal only for frequencies within a band of frequencies. The circuit shown is basically low-pass and high-pass active filters in series. The band-pass low and high cutoff frequencies are then calculated using Eqs. 29.1 and 29.2.
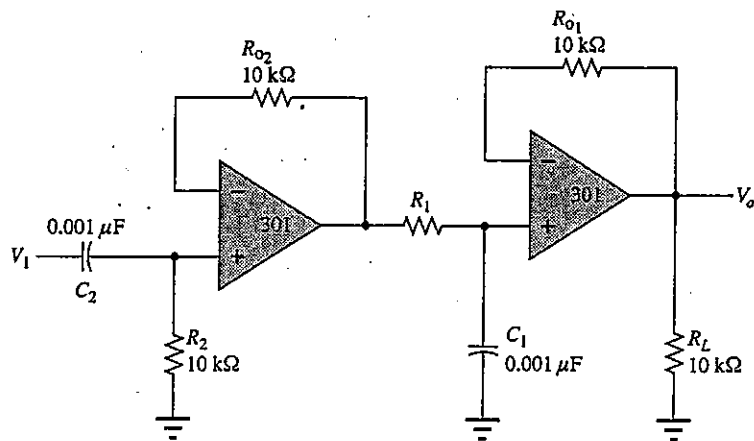

Figure 29-3

PROCEDURE

Part 1. Low-Pass Active Filter

a. For the circuit of Fig. 29.1 calculate the low cutoff frequency using Eq. 29.1.

f_L (calculated) = _____

b. Construct the circuit of Fig. 29.1. Apply an input of 1 V, rms. Vary the signal frequency from 100 Hz to 50 kHz while measuring and recording the output voltage in Table 29.1.

TABLE 29.1 Low-Pass Filter

f	100-Hz	500-Hz	1-kHz	2-kHz	5-kHz	10-kHz	15-kHz	20-kHz	30-MHz
V_o									

c. Plot the output gain-frequency response curve in Fig. 29.4.

d. Obtain the value of low-cutoff frequency from the data plotted in Fig. 29.4.

$$f_L \text{ (measured)} = \underline{\hspace{3cm}}$$

Compare the low-cutoff frequency calculated in step 1(a) with that obtained in step 1(d).

Part 2. High-Pass Active Filter

a. Using Eq. 29.2, calculate the high-cutoff frequency for the circuit of Fig. 29.2.

b. Construct the circuit of Fig. 29.2. Apply an input of 1 V, rms. Vary the signal frequency from 1 kHz to 300 kHz and record the resulting output voltage in Table 29.2.

TABLE 29.2 High-Pass Filter

f	1-kHz	2-kHz	5-kHz	10-kHz	20-kHz	30-kHz	50-kHz	100-kHz	300-kHz
V_o									

c. Plot the data obtained in Table 29.2 in Fig. 29.5.

d. Using the plot in Fig. 29.5 obtain the high-cutoff frequency.

$$f_H \text{ (measured)} = \underline{\hspace{3cm}}$$

Compare the high cutoff frequency calculated in step 2(a) with that measured in step 2(d).

Part 3. Band-Pass Active Filter

a. Calculate the band-pass frequencies using Eqs. 29.1 and 29.2.

b. Construct the circuit of Fig. 29.3.

c. Apply an input signal of 1 V, rms. Vary the signal frequency from 100 Hz to 300 kHz and record the output voltage in Table 29.3.

TABLE 29.3 Band-Pass Filter

f	100-Hz	500-Hz	1-kHz	2-kHz	5-kHz	10-kHz	15-kHz	20-kHz	30-MHz
V_0									

f	50-kHz	100-kHz	200-kHz	300-kHz
V_0				

d. Plot the data in Fig. 29.6. Using the plot determine the lower and higher cutoff frequencies for the band-pass filter.

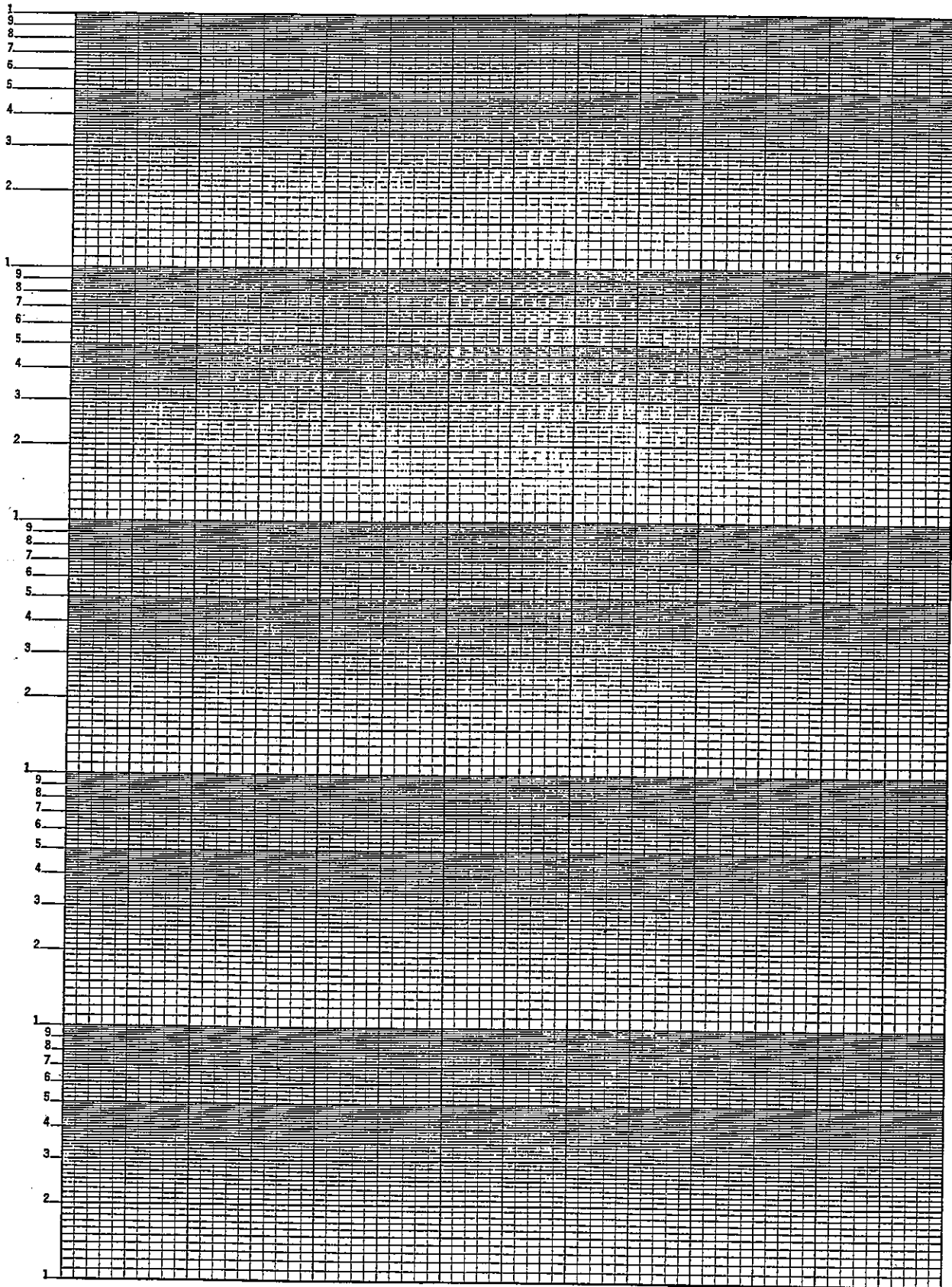Compare the frequencies calculated in step 3(a) with those measured in step 3(d).

Figure 29-6