EXPERIMENT #3
FEEDBACK

OBJECTIVE
Studying the effects of feedback on amplifier characteristics.

THEORY
An electronic feedback amplifier is one in which an electrical signal is transmitted in some manner from output to input as well as from input to output. Feedback can be either negative or positive. In amplifier design, negative feedback is applied to affect one or more of the following properties:

1. Desensitize the gain; that is, make the value of the gain less sensitive to variations in the value of circuit components, such as variation caused by changes in temperature.
2. Reduce nonlinear distortion; that is, make the output proportional to the input, by making the gain independent of signal level.
3. Control the input and output impedances; that is, increase or decrease input and output impedances by selection of appropriate feedback topology.
4. Extend the bandwidth of the amplifier.

All of the above desirable properties are obtained at the expense of a gain reduction. *Figure 3-1* shows the basic structure of a feedback amplifier.

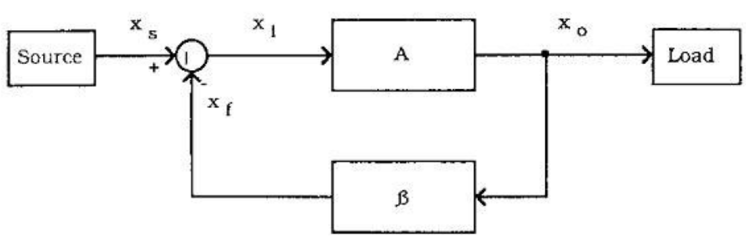


Figure 3.1 Signal Flow Diagram of the Feedback Amplifier

The basic differential amplifier circuit is given in *Figure 2-1*. The voltage difference between two inputs is called the differential-input voltage, *vd*, and the average of these two voltages is called the common-mode input voltage, *vc*.

The open-loop amplifier has a gain, A:

$$x_o = Ax_i$$

The output, x_o, is feed to the load as well as to a *feedback network*, which produces a sample of the output.

$$x_f = \beta x_o$$

This feedback signal, x_f, is subtracted from the source signal, x_s, to produce the signal x_i, which is the input to the basic amplifier.

$$x_i = x_s - x_f$$

The gain of the feedback can be obtained by combining the above equations:

$$A_f = \frac{x_o}{x_s} = \frac{A}{1+\beta A}$$

The quantity, βA, is called the loop gain. The quantity, $D = 1+\beta A$, is the desensitivity factor. This derivation assumes that the source, the load and the feedback network do not load the basic amplifier. Another basic assumption is that the forward transmission occurs entirely through the basic amplifier and the reverse transmission occurs entirely through the feedback network. For an amplifier whose high frequency response is characterized by a single pole, the gain can be expressed as:

$$A(s) = \frac{A_M}{1 + s/\omega_H}$$

where A_M is the midband gain, and ω_H is the upper 3-dB frequency. Application of negative feedback, with a frequency independent factor β, around this amplifier results in a closed-loop gain, $A_f(s)$, given by

$$A_f(s) = \frac{A(s)}{1 + \beta A(s)} = \frac{A_M/(1+\beta A_M)}{1 + s/\omega_H(1+\beta A_M)}$$

Thus the feedback amplifier will have a midband gain of $A_M/(1+\beta A_M)$ and an upper 3-dB frequency, ω_{Hf}, given by

$$\omega_{Hf} = \omega_H(1+\beta A_M)$$

The upper 3-dB frequency is increased by a factor equal to the amount of feedback. Similarly, it can be shown that if the open-loop gain is characterized by a dominant low frequency pole giving rise to a lower 3-dB frequency, ω_L, then the feedback amplifier will have a lower 3-dB frequency, ω_{Lf}.

$$\omega_{Lf} = \omega_L/(1+\beta A_M)$$

PRELIMINARY CALCULATIONS

1. For the feedback amplifier below, calculate the DC operating points of the transistors.

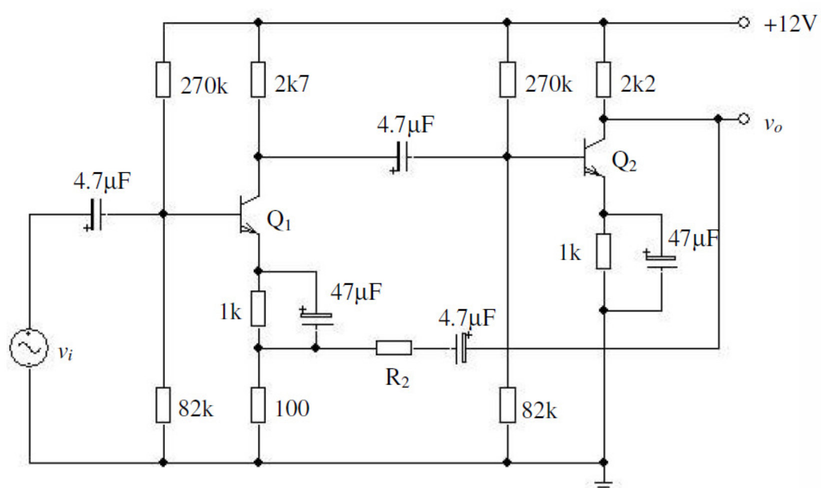


Figure 3.2 Experimental Feedback Amplifier

2. Calculate β, A_{vf}, R_{if}, R_{of} of this amplifier for R_2 = 4k7, using the low-frequency *h-parameter* model. Which type of feedback topology is used in this amplifier?

3. Repeat step 2 for $R_2 = 47k$

PROCEDURE

1. Build the circuit shown in *Figure 3-2* without feedback (remove *R*2). Apply a 1mV (peak-to-peak), 1kHz sine wave at the input. After adjusting it so that a distortionless waveform is obtained at the output, measure *vo*. From measured data, calculate *Av*.

Av = ...

Measured values : *VCEQ* (Q1) = ... *ICQ* (Q1)= ....

VCEQ (Q2)= .... *ICQ*(Q2)= ....

2. Set *R*2 = 4k7. Measure *Avf*. Compare the experimental result with that of calculated value.

Avf (calculated) = ... *Avf* (measured) = ...

3. Measure the input impedance, *Rif*, of the feedback amplifier. Compare your measured value with the value you calculated in preliminary calculations. Is this value less than or greater than *Ri* without feedback? Why?

Rif (calculated)= .... *Rif* (measured) = ...

4. Measure the output impedance, *Rof* (with load resistance included), of the amplifier. Compare the measured data with the one you calculated theoretically. Is this value less than or greater than *Ro'* without feedback? Why?

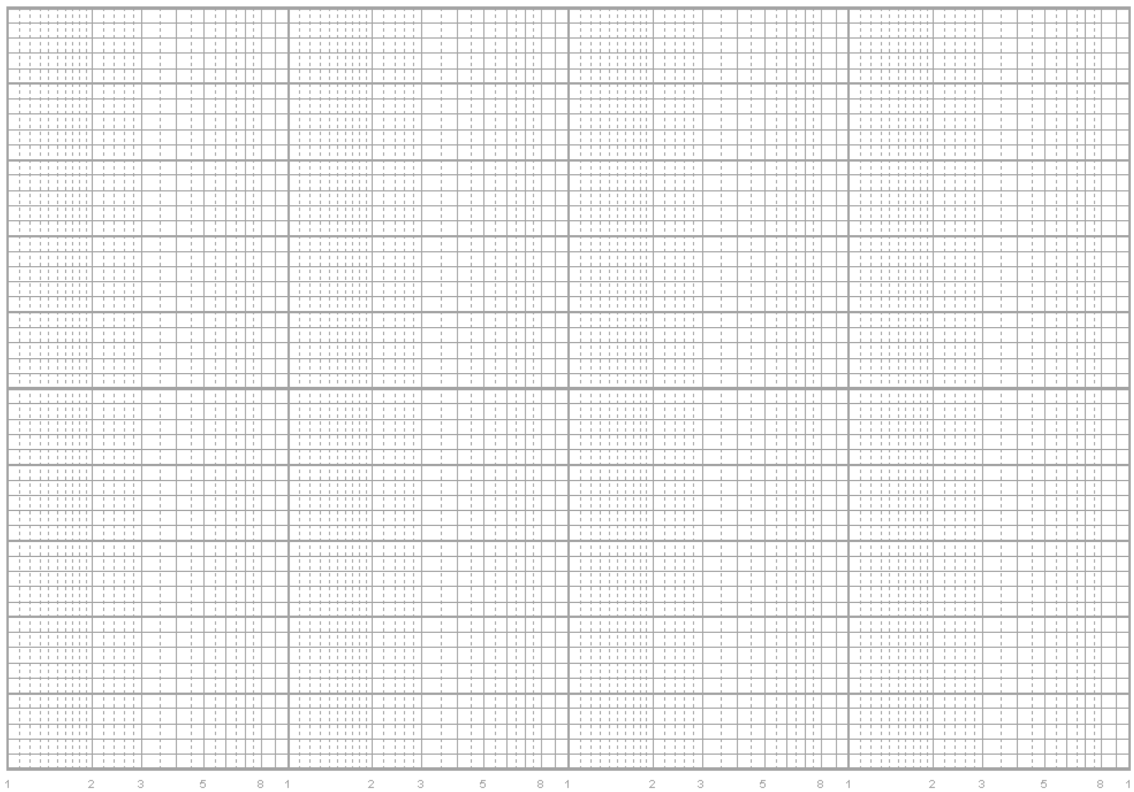
Rof (calculated)= ....*Rof* (measured) = ...

5. Keeping the input voltage constant, change its frequency to take enough data to make a rough plot of the frequency response of the amplifier. Measure the upper and lower 3-dB frequencies.

f (Hz)	10	20	50	100	200	500	1000
20 log (v_o / v_r) (dB)							0

f_L = ... f_H = ...

6. Sketch the Bode magnitude plot of A_{vf} on a semi-log paper.



7. Repeat steps 2 through 6 for *R*2 = 47k.

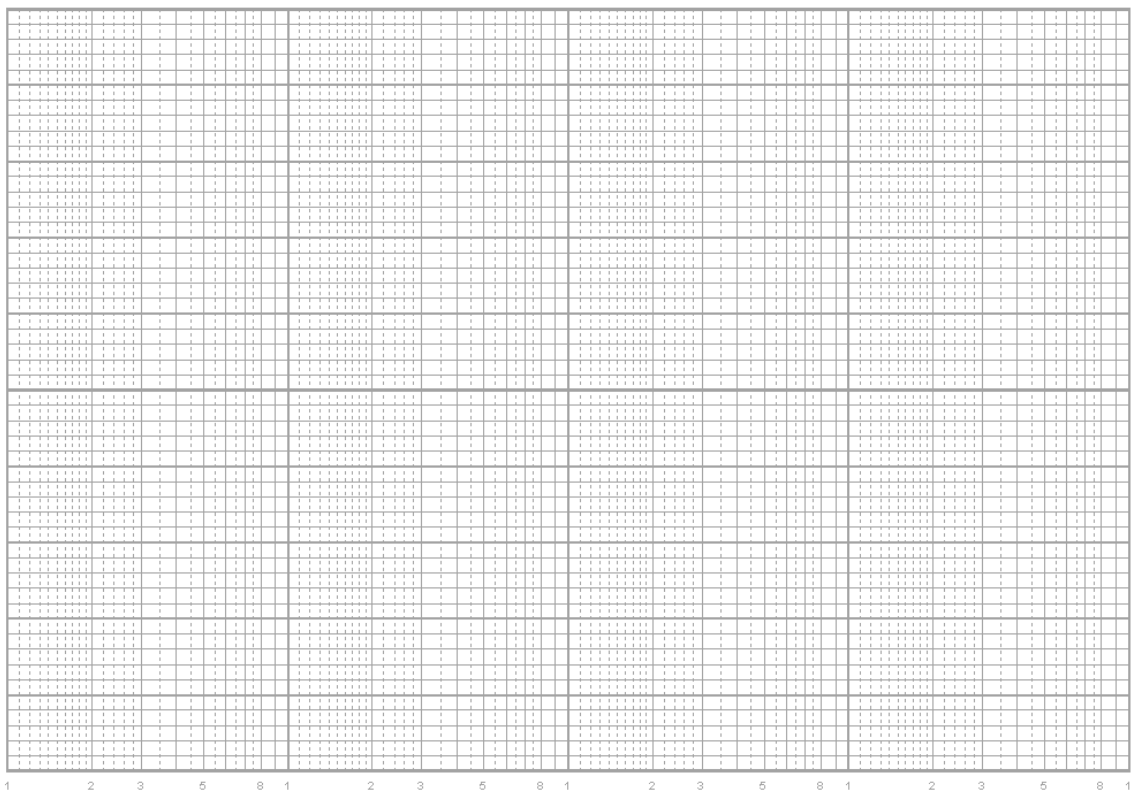
Avf (calculated) = ……….. *Avf* (measured) = ………..

Rif (calculated)= ....……. *Rif* (measured) = ...

Rof (calculated)= .....……... *Rof* (measured) = ...

f (Hz)	10	20	50	100	200	500	1000
20 log (v_o / v_r) (dB)							0

f_L = ... f_H = ...



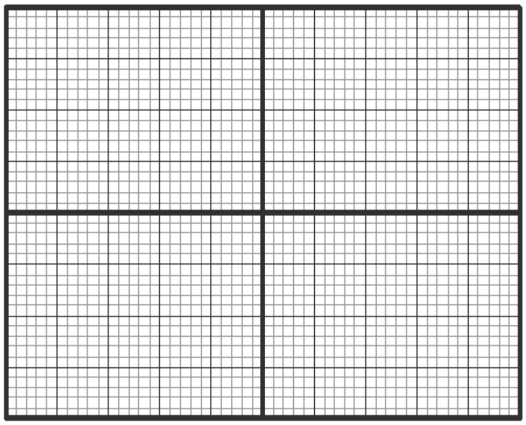
EQUIPMENT

1. CRT oscilloscope
2. Audio signal generator
3. Electronic A.C. voltmeter
4. Decade resistor box
5. Bread-box

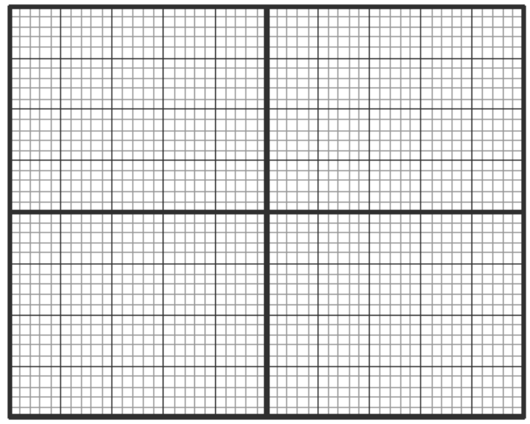
COMPONENTS

1. Transistors (2) :BC238B or equivalent
2. Capacitors: 4.7μF (3), 47μF (2)
3. Resistors: 270k (2), 82k (2), 47k, 2k7, 2k2, 1k (2), 100Ω

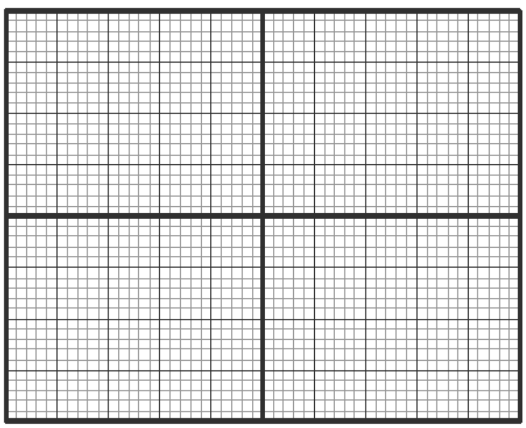
Input



Outputs



Input



Outputs