CHAPTER III

A Method to Reduce the Positive Feedback in An Audio System

The stability of an audio system can be increased by the method of frequency shifting. From the theoretical point of view the stability of the system should not depend on the magnitude of the frequency shift, but in practice the frequency of the system must be shifted by a certain minimum amount before a sensible additional gain can be obtained. in this chapter , basic discussion will be given on the magnitude of the frequency shift and the frequency shifting system.

3.1 Room Frequency Response

Room frequency response between two locations with negligible direct sound transmission is not smooth over the audio frequency band. It appears as peaks and valley with the spacing between them depending largely on the reverberation time, so that most rooms having approximately the same reverberation time will show the same spacing between adjacent peak and valley

In 1962 Schroeder, and Kuttruff [6.] showed that the average frequency spacing between adjacent peak and valley of the room frequency response curve is equal to $\frac{4}{T_{60}}$, where T_{60} is the reverberation time.

An example of room frequency response curve between two locations with negligible direct sound transmission [5] is shown in Fig. 3.1. Major peaks occur at an average frequency spacing of about 10 Hz.

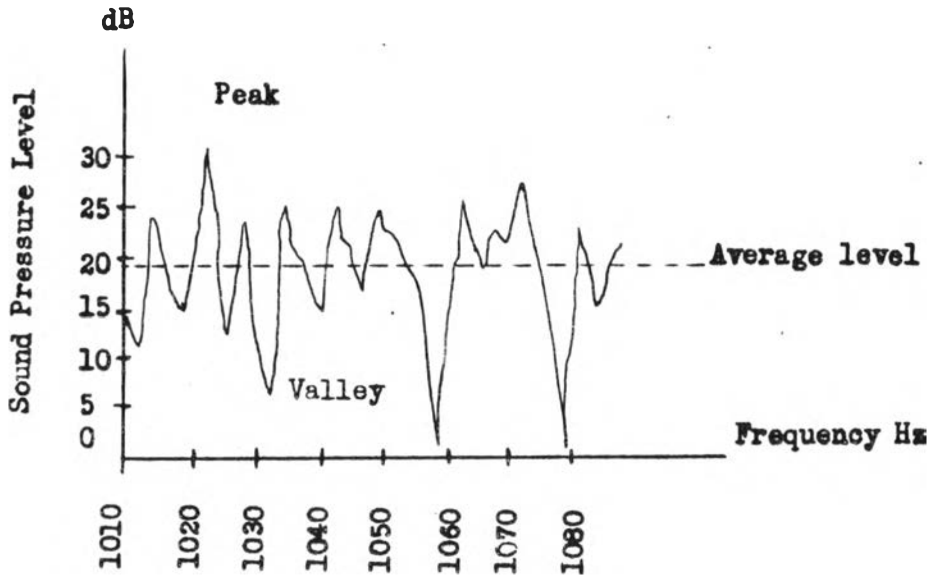

Fig. 3.1 Frequency Response Curve of A Room

The average sound pressure level fluctuation between a peak and a **vally** is about 10 dB and the extreme variations cover a range of 30 dB or more. The highest peak exceeds the average level by more than 10 dB; this will cause the system to be unstable.

The purpose of slightly shifting the frequency by an amount equal to the average spacing between peak and adjacent valley is to reduce the peak gain by using the low gain characteristic of the valley on the next trip. So the magnitude of the frequency to be shifted will be the difference between the frequency of the peak and that of the adjacent valley, which is about 5 Hz. See Fig. 3.1

3.2 Optimum Frequency Shift

In 1964 the measurements of the additional stable gain [5] as a function of the magnitude and sign of the frequency shift were taken in a large auditorium, a medium size room, and a small sound-proof room. The result [5] showed that the optimum frequency shift is equal to the average spacing between peak and adjacent valley of the room frequency response or about $\frac{4}{T_{60}}$.

The larger shifts do not give any better improvement and in some cases are even less effective.

There is also no significant difference between positive and negative shifts. That experiment leads to the conclusion that the optimum frequency shift for most room is about 4 Hz to 12 Hz. [5]

3.3 Frequency Shifting Method

There are many methods which can be used to shift the frequency. The method we use here has the same principle similar to that of an analog computer. The input signal with a frequency f is shifted by a magnitude of Δf, to get the output signal with a frequency $(f + \Delta f)$.

Let us consider a sinusoidal signal of frequency f its instantaneous voltage V_i with peak voltage V_p is represented by

$$V_i = V_p \sin 2\pi ft$$

V_i with 90° phase difference is represented by

$$V_i' = V_p \cos 2\pi ft$$

In order to stabilize the system the output signal frequency should be shifted by an amount of Δf then

$$V_o = V_p \sin 2\pi (f + \Delta f)t$$

$$= V_p \sin (2\pi ft + 2\pi \Delta ft)$$

$$= V_p \left[\sin 2\pi ft \cos 2\pi \Delta ft + \cos \pi ft \sin 2\pi \Delta ft \right]$$

The signals $V_p \sin 2\pi \Delta ft$ and $V_p \cos 2\pi \Delta ft$ are the frequency shifting signals in quadrature which are generated by an oscillator. Let us represent these signals by

$$V_s = V_p \sin 2\pi \Delta ft$$

and V_s with 90° phase difference by

$$V_s' = V_p \cos 2\pi \Delta f t$$

then

$$V_o = V_i \cdot V_s' + V_i' \cdot V_s \quad \text{.................}(3.1)$$

From Eq. (3.1) one can design a system for processing the input signal frequency to be shifted by an amount of Δf.

The whole system consists of a phase shift network, a pair of signal multipliers; a signal summing circuit, and a quadrature signal generator as shown in Fig. 3.2.

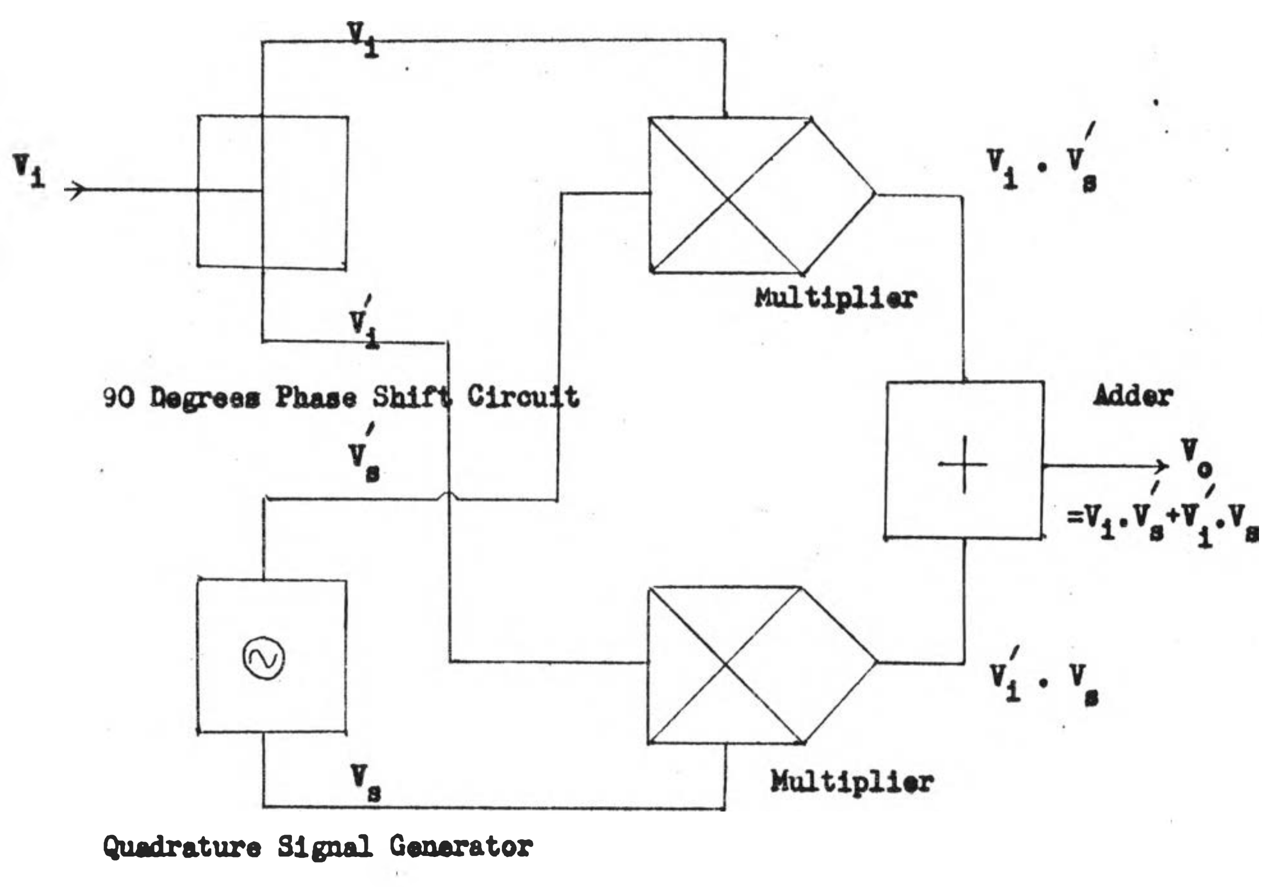

Fig. 3.2 Frequency Shifting System.