Noise Cancellation Headphone:

Targets:

a) To design and implement an analog system for noise cancellation in headphones.

b) To achieve 20 decibel (dB) attenuation, when a noise of 100 Hz frequency is applied.

c) To design an analog compensator to stabilize the system, i.e. loop shaping of the loop transfer function is performed in order to achieve the desired objective.

Control system

Consider the block diagram of a basic control system (with external noise):

![Block diagram of closed loop system](image)

**Fig 1: Block diagram of closed loop system**

The closed loop transfer function of the system is given by:

$$\frac{G(s)}{1 + G(s)H(s)}$$

For high gain with unity feedback, the output-input ratio is given by:

$$\frac{G(s)}{1 + G(s)H(s)} \approx 1 \text{ (Equation 1)}$$
The noise to output transfer function is given by:

\[
\frac{1}{1 + G(s)H(s)} \approx \frac{1}{G(s)} = 20(dB) \quad (\text{according to objective})
\]  

(Equation 2)

System Identification

For achieving 1 and 2 in the headphone system, the open loop response for the same is plotted. Sinusoidal waves of varying frequency are applied to the headphone input (100 Hz – 10000 Hz). The output is sensed by the microphone and its biasing circuit (a PCB for the biasing circuit will be provided, for the circuit, see the appendix). The block diagram of the open loop system is shown below:

![Block Diagram](image)

**Fig 2: Open loop system**

From equation 2, in order to achieve an attenuation of 20dB a suitable gain is added to the forward path. Sample magnitude and phase plots after introducing suitable gain are given below:

![Magnitude Plot](image)

**Fig 3: Magnitude plot**
But introducing such high gain into the system will make it unstable. So in order to stabilize the system, a compensator is to be designed to stabilize it.

The block diagram of the closed loop system is shown below:

![Block diagram of the closed loop system](image)

**Fig 5: Block diagram of the closed loop system**
Appendix

**Fig 6: Biasing circuit**