Resonances of a loudspeaker

Introduction

In this experiment you will use analogue techniques to invstigate the resonances of a loudspeaker, find out what causes them, and see how they can be eliminated.

Locating the resonances

Connect the loudspeaker to a signal generator via a 100 Ω resistor; also connect the signal generator to one channel of the oscilloscope. Connect the second channel of the oscilloscope directly to the loudspeaker, as shown in figure 1.

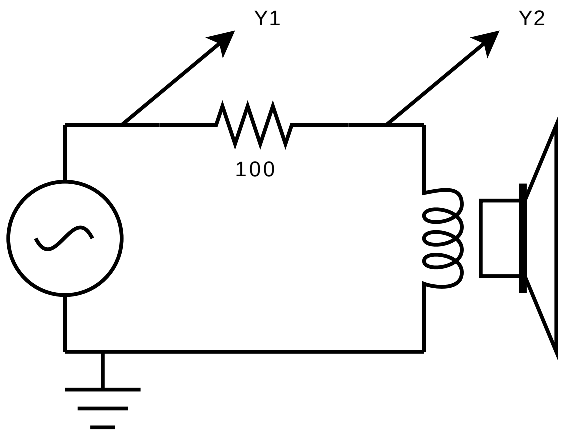

Figure 1: Connection of loudspeaker

Using a sine wave, sweep the generator frequency and observe the drive waveform (Y1) and the response waveform (Y2) on the oscilloscope. You will probably see a strong peak in the response at a low audio frequency. This resonance indicates that the speaker, and this way of driving it, are not of high quality.

Clearly, Y1 is the applied signal. The peak that you see in Y2 coincides with the frequency at which the sound is loud, and it is in fact it is closely connected with the motion of the loudspeaker cone. Find out how a loudspeaker works, and hence explain why motion of the cone produces voltage at Y2. You can confirm this is the case by turning down the applied signal and *gently* vibrating the cone with your fingers. Please be gentle, as loudspeakers are easily destroyed like this. An understanding of how the loudspeaker works will also make clear why Y1 is proportional to the force that normally moves the loudspeaker cone. Write your obervations and explanations in your lab book.

Measure the ratio Y2/Y1 as a function of frequency and plot the resonance curve. Note how the phase relationship between Y1 and Y1 varies across the resonance; there is no need to measure it in detail. Estimate the Q of the resonance, that is, the ratio of resonant frequency to the width of the peak (measured half-way up: the "full width at half height").

Can you find a resonance at any other frequency? The next section should help.

Lissajous figures

It is easier to locate resonances by looking at the phase relationship between force and response rather than the ratio of amplitudes. At resonance, the phase difference changes rapidly, in fact in the present system it goes through zero. Switch the oscilloscope to X/Y mode. The pattern it draws is known as a Lissajous figure, and in this case should be an ellipse. Why is this?

At resonance, the ellipse collapses into a diagonal line (why?). By watching for this effect, set the generator frequency to the resonance. You should be able to find a second resonance more easily this way, so measure its frequency also.

Identifying the resonances

Even when we know the resonant frequncies, we may not know what is resonating: where is the effective mass, and where is the effective spring? Perform some experiments to find out. *Gently* add one or more pea-sized pieces of Blutak to the center of the loudspeaker cone (to increase its mass). If either of the resonant frequencies changes as a result, plot the frequency vs. added mass.

In the side of the loudspeaker, there is a hole that can be blocked by a bung. Examine the effect of blocking and unblocking the hole on the resonances.

What do your results tell you about the origin of the resonances?

Damping the resonances

As configured here, the loudspeaker would not be very useful in a sound systems because its resonances give it an uneven frequency response. Add a 10 Ω resistor in parallel with the loudspeaker (at signal Y2) and re-measure the main resonant peak. You will have to turn the amplitude up to compensate for losses in the resistor, but concentrate on the frequency and Q of the main resonance. Why is it suppressed?

Transient response

Look at the response of the loudspeaker to a square wave at about 5 to 10 Hz. What kind of oscillations do you see, and why? Investigate the effect of the 10 Ω resistor. In fact, tests like this can reveal a lot about any signal processing system.

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