Step 1: Assemble all the parts

To make a loudspeaker-based ultrasonic levitator the main things you need are a low voltage sine wave generator, an amplifier and a loudspeaker. You will also need a metal plate and some clamp-stands or some other way of holding the various bits in place as well as some small polystyrene balls to levitate. This levitator is designed to work at a frequency (or pitch) of around 25 kHz which is above the audible range of humans, that’s why it’s called an ultrasonic levitator. There are good reasons for doing this. First, the sound levels needed for levitation are very high and so it’s preferable not to be able to hear them. Second, the acoustic forces go up with frequency so levitation works better at ultrasonic frequencies.

The Parts

The sine wave generator: There are lots of options here from high end function generators to DIY circuits. Which you choose will depend on your wallet and your electronic skills. The bottom line is that whatever you choose, it must be able to generate a sine wave in the frequency range 20-30 kHz and an amplitude in the range 1-5 Volts (peak-to-peak). As this frequency is above the audible range, your computer, and most digital audio equipment, will not be able to do this which is a shame! If you search for Audio Generators or Waveform Generators you will find a number of good cheap options (in the £50-200 range). Alternatively, for a few pounds, you can build your own and there are many web resources to help you do this (see for example, www.ti.com/lit/wp/snoa839/snoa839.pdf).

The amplifier: Here, a good quality audio amplifier is needed or, if you can get your hands on one, a research amplifier. Go for 100 Watts or more power and make sure it can amplify old fashioned analogue signals. A simple separate amplifier is best, the fewer the knobs, the better. For obvious reasons, none of the audio manufacturers guarantee their amplifiers into the ultrasonic range, so a leap of faith is needed. If you can borrow and test the amplifier first, that’s perfect. But our experience is that they all work in the low ultrasonic range we use.

The loudspeaker: Here you need a high power tweeter or compression horn tweeter. These are standard diaphragm loudspeakers designed to work at high audio frequencies – we take them a bit further into the ultrasonic range! Not many manufacturers give information on their ultrasonic performance, however, given that this type of speaker is quite simple in design, we would expect most to work. One exception is www.bmsspeakers.com who say that their speakers work fine up to 30 kHz and we agree.

The object: Here we levitate small polystyrene balls. These are very light and so are one of the easiest type of object to levitate. They are also easy to find as they are widely used in packaging. We recommend you start with balls in the range 1-2 mm.

Other bits and pieces: You will need some way of holding the speaker firmly in position, we use a clamp-stand. The final part is a metal plate which acts a reflector, and a means of holding it in position. Here we use a lab-jack as a plate with a built in height adjustment – very useful.

Fig 1 A high-end signal generator and research amplifier connected to a high power tweeter loudspeaker.
Step 2: Putting the levitator together

Getting the right components is the hard bit, from now on things are easier and more fun. Connect the signal generator to the amplifier. Probably round the back, the amplifier will have an input socket and this is where you should connect the signal generator. There will also be an output (or speaker) socket, to which you connect to the loudspeaker. So far this is just a standard audio system so you can use the manufacturer’s instructions to help. Don’t forget that as you only use one speaker it’s acting like a mono hi-fi, and so you only need to connect to one of the speaker sockets. You can then test it at an audible frequency, say 1 kHz, to see that it’s all working (see figure 1).

Step 3: Achieving levitation

To get levitation you need to generate a standing wave. This is done by trapping the sound from the loudspeaker using a metal plate. As the sound bounces up and down between the speaker and plate its intensity increases and, if the conditions are right, the standing wave is formed.

The most important thing now is to tune the distance between the speaker and the plate. This will need to be right to within a couple of millimetres, so it’s a challenge and patience is needed (see Figure 2). We use a clamp-stand to hold the speaker and a lab-jack to allow us to adjust the height of bottom plate. It’s also important to get the sound levels right: too low and the forces will not create levitation, and too high and the amplifier will be over-loaded.

Start with the plate about 50 mm from the speaker, the signal generator on 1V and the amplifier set to one quarter of its maximum. Sprinkle some small polystyrene balls onto the bottom plate, keeping a careful eye on the balls. When they start to jiggle around you are close, so slow down and adjust until the balls jump up and levitate automatically. You can also try putting the balls directly into the stable positions with tweezers (see figure 3). If they don’t levitate, increase the levels on the signal generator or amplifier and repeat. You may also have to adjust the drive frequency to get the most out of your chosen speaker. Then, see how many balls you can levitate?

Feedback – We would love to hear about your levitator
What combinations of component parts did you use, how well did it work, any nice photos of levitation? Please contact us at ultrasonic.levitator@gmail.com

Caution: Please remember that as this experiment involves electricity, care is needed and manufacturer’s instructions should be followed. Also, if you find any of the sound emitted uncomfortable, use ear-plugs.