The Phenomenal Levitating Ball

The Phenomenal Levitating Ball is a kit designed to demonstrate that an ultrasonic standing wave is able to support small objects suspended in space. The kit was inspired by an article in MAKE magazine by Ulrich Schmerold (https://makezine.com/projects/micro-ultrasonic-levitator).

Construction

First separate the circuit board into its individual component parts (main board + 4 smaller boards). They can be snapped at the 'mouse bites' by hand or by using pliers. File or sand the remains of the mouse bites if desired.

Test fit the parts together (see photograph below of the completed kit). The tabs on the smallest boards are designed to fit into matching slots in the main board. Depending on the tolerance of the board fabrication the tabs may need slightly reducing in size in order to obtain a tight fit. Use a flat file or sandpaper for this. Be careful not to make the fittings too loose as this will make soldering them together harder.

Fit and solder the resistor (R1) to the main circuit board and trim its legs.

Next fit the chip sockets (IC1 and IC2) matching the notch in the socket against the notch in the symbol on the board. Care should be taken when soldering these components to avoid solder bridges between the pins. It is not recommended that the chips are soldered directly to the board.

Fit and solder the capacitors paying attention to the polarity of the electrolytics C3 and C4 (negative is marked by a stripe on the side of the body). The ceramic capacitors (C1 and C2) can be fitted either way around.

Solder the regulator (REG) matching the shape to the symbol on the board. Solder the LED (LED1) matching the shorter leg (also flat on the rim) to the hole with the line.

Solder the pushbutton (S1).

Solder the ultrasonic transducers to the small boards marked TX1 and TX2 (the two transducers are identical). They have a polarity with the positive pin marked by a small flange on the underside. This pin should match the + sign on the board. In fact it doesn't matter which pin you treat as positive so long as you are consistent. If it isn't obvious then don't worry about it as the polarity can be adjusted in software.

Fit the two pairs of battery connectors (BAT+ and BAT-) to their respective boards matching the shape to the symbol - the hexagonal connectors are positive (both soldered to the board marked 'LEFT') and the circular are negative (both soldered to the board marked 'RIGHT'). Make sure the connectors are pushed fully into place and are square with their boards. Use plenty of solder to make them mechanically strong.

Slot the two small boards containing the ultrasonic transducers into their matching slots in the main board pointing towards each other. It is important that they are at right angles to the main board. Solder them in place using plenty of solder at the top and bottom.

Slot the two boards containing the battery connectors into the main board (see photograph below). Temporarily use a PP3 battery attached to the lower pair to hold the two boards at the correct separation

and angle. Solder them in place using plenty of solder on both sides at the top and the bottom, inside and out. These are mechanical as well as electrical joints.

Don't fit the chips into their sockets until you have thoroughly checked your construction. Check that all the components have been inserted correctly and that there are no dry joints and no solder bridges between pins. Then match the small notch in each chip to the notch in its socket.

Finally connect a pair of 9V PP3 batteries to the battery connectors. If the board is functioning correctly the LED should flash twice.

How to Use

Use the small piece of wire mesh held with a pair of pliers (or perhaps glued to a cocktail stick) to insert objects into the space between the transducers. Place an object such as a small fragment of paper or packing foam, a couple of millimetres or so in size, onto the wire mesh then gently ease it into position. Move it up and down until you find a point at which the object is supported then gently remove the mesh. The object will remain suspended in space.

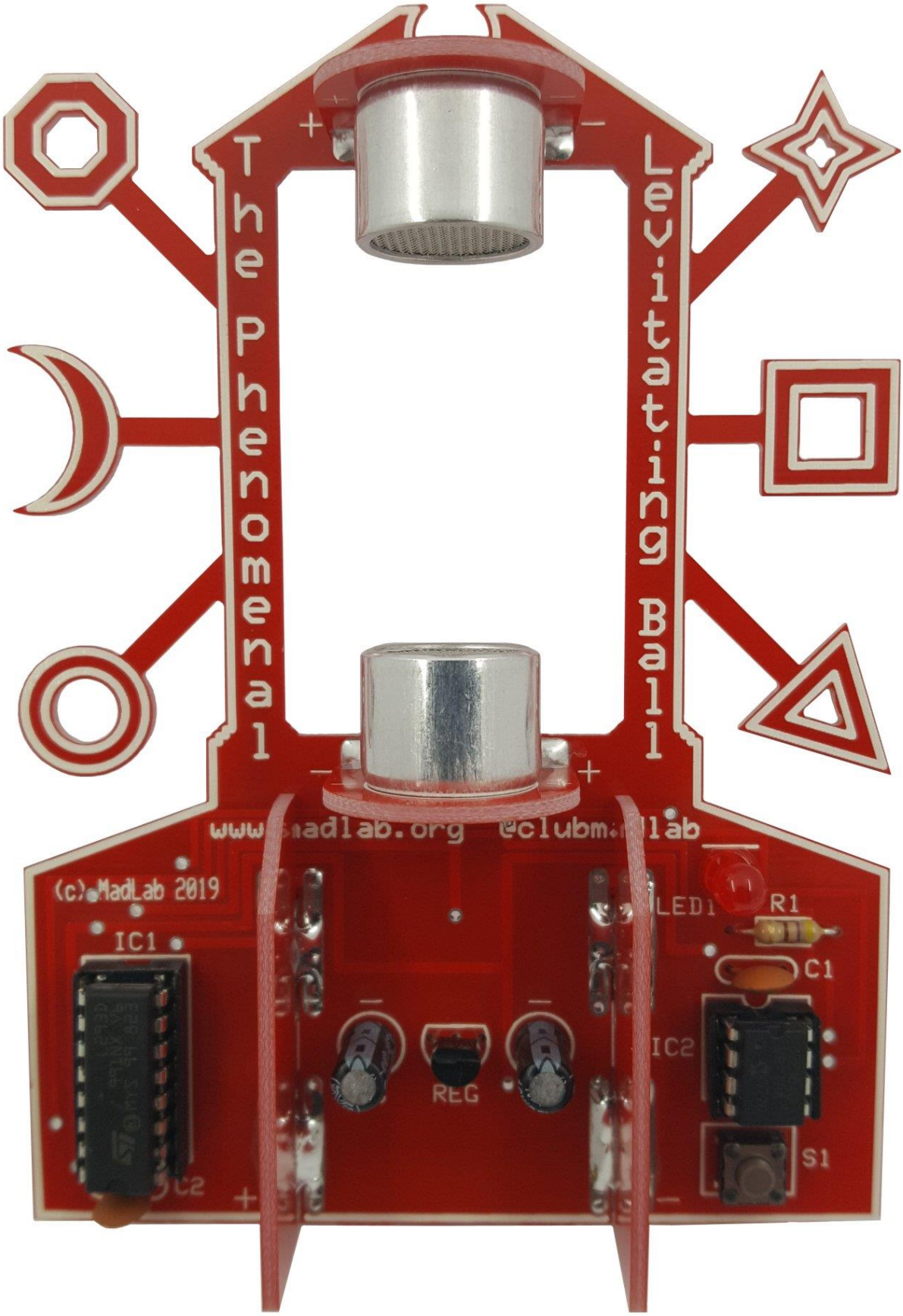
It takes some practise and a steady hand to do this. Note that only very light objects can be supported.

It’s possible for multiple objects to be suspended at the same time at different ‘nodes’ of the standing wave.

As mentioned above the transducers’ relative polarity can be changed. To do this connect the lower battery while the pushbutton is held down. This will toggle the relative phase (in phase or out of phase) of the waveforms to the two transducers. The setting is saved in non-volatile memory and an extra LED flash during power-up indicates the 180 degree phase shift. You can try both settings and see which works better.

During normal operation pressing the pushbutton enables a ‘tractor beam’. The phase angle between the excitation pulses is slowly swept up and down with the sweep rate increasing over time. This alters the position of the standing wave nodes. Any suspended object (if not too heavy) will be moved up and down a few millimetres.

It is recommended that good quality alkaline batteries are used. The current drawn is about 40mA from the lower battery and 80mA from the upper. Periodically swap the batteries over to even out the load.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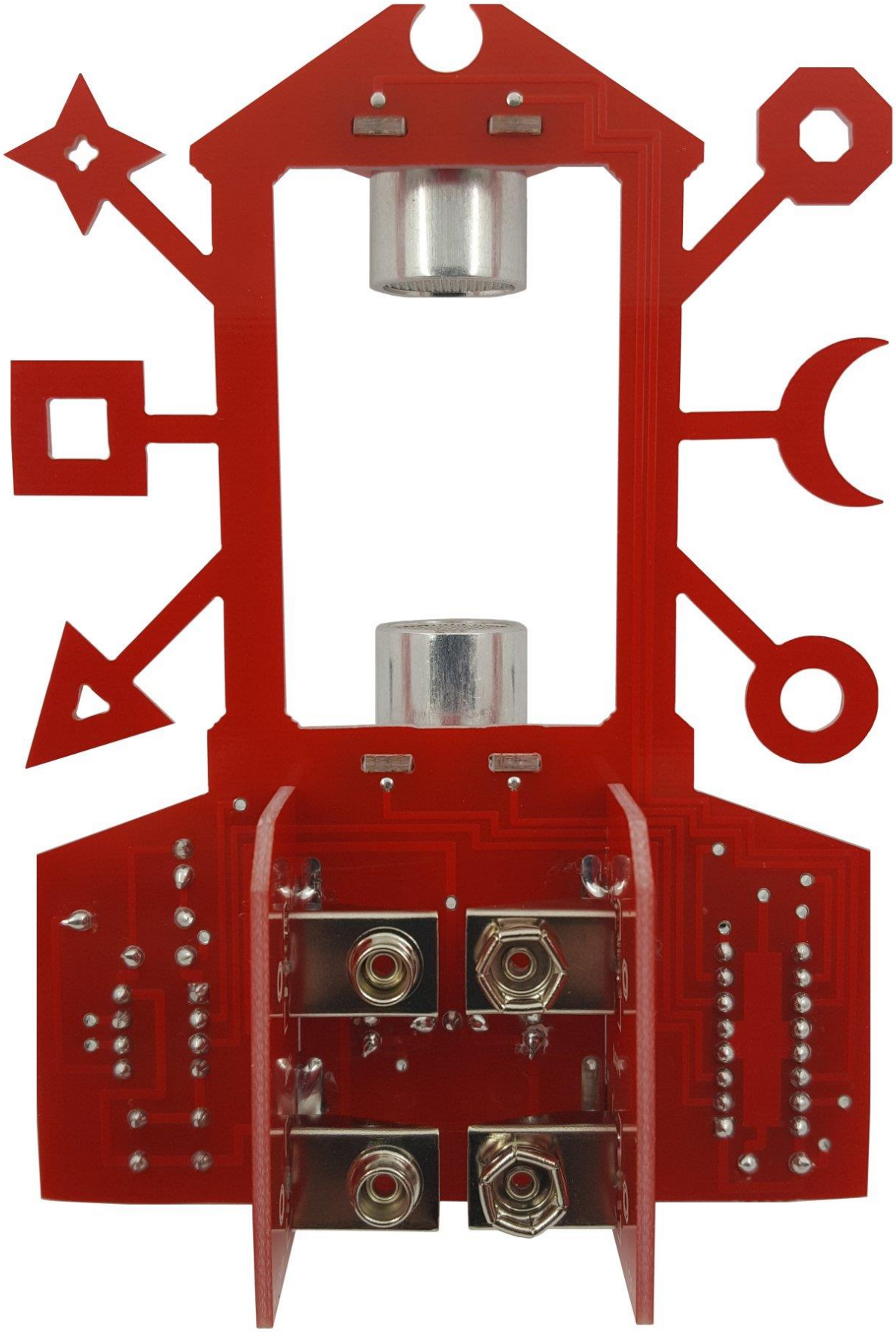
IC1
LED1
R1
C1
IC2
REG
S1
C2



Component list

Resistors

R1	470R (yellow, purple, brown, gold)

Capacitors

C1, C2	100nF ceramic (brown, marked ‘104’)
C3, C4	10uF electrolytic (blue or black)

Semiconductors

REG	78L05 5V regulator (black)
LED1	5mm red
IC1	L293D H-bridge + 16-pin socket
IC2	PIC12F1840 microcontroller + 8-pin socket

Miscellaneous

TX1, TX2	ultrasonic transducers
S1	miniature tactile pushbutton
BAT+, BAT-	battery connectors, 2 pairs
Wire mesh	

PCB

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