Supplementary Materials

The circuit is chosen in order to meet the following design considerations: high voltage output with high gain ratio, low power consumption in order to be easily powered by batteries, few number of components, low cost, compact and rapidly prototyped. The boost DC (Direct Current) to DC converter can run in two modes: Continuous Conduction Mode (CCM) and Discontinuous Conduction Mode (DCM). It is easier to generate higher voltages with larger amplification factor in the DCM mode. The voltage amplification ratio between the input and the output voltage without accounting for the losses can be expressed as [1]:

$$\text{gain} = \frac{V_o}{V_i} = \frac{1 + \sqrt{1 + \frac{2D^2 V_o}{f_s L I_o}}}{2} \tag{1}$$

where V_o and V_i are the output and input voltages, respectively, f_s is the switching frequency, D is the duty cycle, L is the inductance, and I_o is the output current.

The circuit in Figure S1 is designed to amplify the battery voltage generated from the two small lithium ion batteries from 8 V approximate up to 800 V. The output voltage can be controlled by either changing the pulses switching frequency or the duty cycle. The pulses required for switching the MOSFET are generated from a 555 oscillator circuit working in stable operation mode as it is shown in Figure S2. The frequency and the duty cycle of the generated pulses are calculated as:

$$f = \frac{1.44}{(R_1 + 2R_2)C} \tag{2}$$

and

$$D = \frac{R_1 + R_2}{R_1 + 2R_2} \tag{3}$$

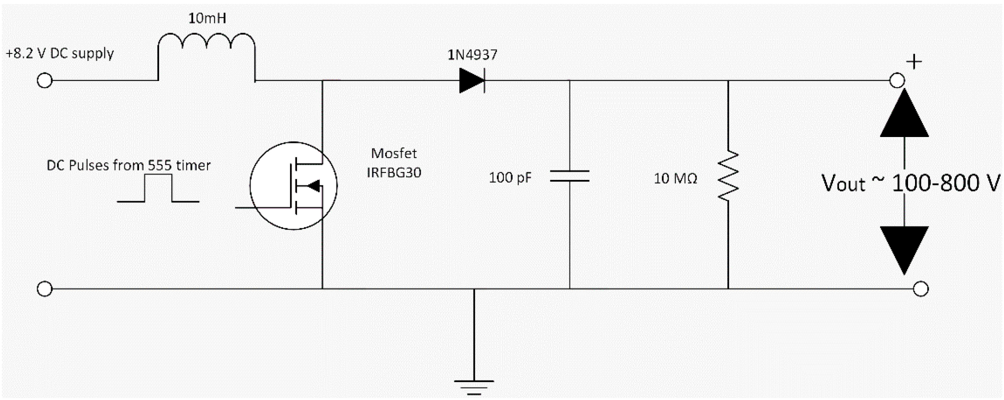

Figure S1. Circuit diagram of the boost DC to DC converter used to generate high voltages from the battery source.

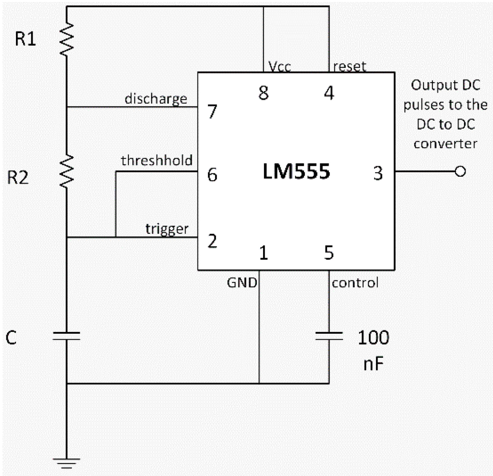

Figure S2. 555 timer circuit used to generate the pulses required for the witched mode power supply.

The circuit is constructed using the five following components: IRFBG30 Power MOSFET, 100 pF capacitor, 10 Mohm resistor, 10 mH inductor and a fast recovery diode 1N4937. The DC signals generated by the boost circuit can be used directly in actuating the droplets. However, some problems occur with prolonged actuation with DC signals such as electrolysis and charge trapping. Using the AC (Alternating Current) signals can solve these problems and they are usually preferred over the DC signals for droplet actuation. Therefore, an additional DC to AC converter circuit is used. This circuit includes a full bridge driver and 4 MOSFETs for chopping the DC signal to a square wave AC signal. The pulses required for operating this circuit are generated from a 555 oscillator circuit working in astable operation mode. A solid state relay (AQV259) is used for controlling the high voltage signal in the switching circuit. The system is powered by small lithium ion batteries (Pukcell 3.7 V 2000 mAh). A 5 V voltage regulator IC (UA7805) is used to provide a stabilized power source for operating the microcontroller and the Bluetooth module safely from the slightly higher voltage output of the lithium ion batteries.

A demonstrative video that shows the motivation behind this work and describes the device in detail is available at the following link: https://www.youtube.com/watch?v=X23JZsN0GLU.

Reference

1. Kazimierczuk, M.K. *Pulse-width Modulated DC-DC Power Converters*; John Wiley & Sons: Hoboken, NJ, USA, 2008.