COST EFFECTIVE DESIGNS OF WEARABLES WITH ULTRALOW POWER BLUETOOTH LOW ENERGY (BLE) FOR BIO-SENSING AND NEUROMODULATION

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The current design of wearable devices requires the combination of multi-disciplined technologies into one product. These technologies span technical materials that could come in contact with skin, electronics, antenna design, usability, comfortability, power consumption and unique manufacturing processes. We present here some key considerations for putting together a neuromodulation wearable formed as a sticker.

WEARABLE DESIGN CONSIDERATION

Every product development begins with the application and product specification. The questions to be considered are:

- Which body part should the device be applied to?
- How can it be attached and held to the body?
- What body curvatures and mechanical flexibilities should the device deal with?
- What mechanical flexibilities should the sticker have?
- Should it be disposable? If reusable – what about cleaning?
- Are there any novel materials used in the Electrodes?

At this point validation testing should be defined so that consequent design could be examined against these tests.

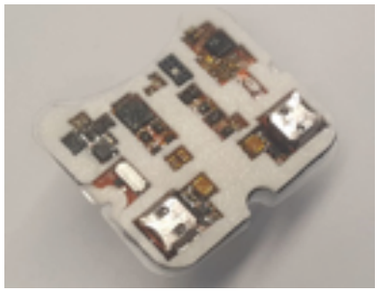
WEARABLE BUILDUP

Neuromodulation wearables send electrical pulses through electrodes attached to the skin; Wearables can be built up by multiple layers; at first electrodes are selected according to required stimulation parameters. Choices between wet electrodes (e.g. gel electrodes) to dry electrodes; when novel materials are used special attention to regulatory and biocompatibility issues should be considered. Selection of the adhesion layer to skin is made which is usually accomplished by biocompatible skin double sided or single sided tapes that on one side stick to the skin holding the electrodes against the skin and on the other side adhere to the upper layer; Conductive carbon based double sided tape is then attached to the electronics stimulation terminal on one side and the electrode body to the other side. Electronics card which should be assembled over a flexible PCB is attached to

this complex. After this an upper insulating soft foam covering layer is attached to electrodes layer forming the final shape of the wearable. This process can be manually implemented or automated and available with many manufacturing and prototyping vendors, clean controlled environments is a must.

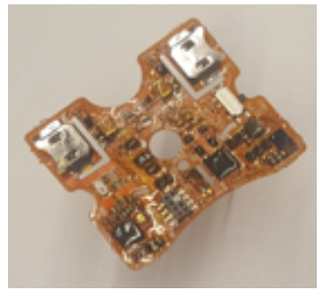
The closer the antenna is to the skin, the more antenna impedance mismatching problems occur. In such cases, careful antenna design and matching should be done. It is wise, however to distance the antenna as much as possible from the skin.

Gel Electrode Layer



Complex with Electronics

Padding Material



Insulating Electronics

SELECTING THE POWER SOURCE

The power source is one of the limiting factors when it comes to a proper commercialization of wearables. It is very difficult to regulate the disposing of wearables when batteries constitute part of the assembly due to environmental concerns and standards. Using rechargeable batteries limits the choice of the disposability of the wearable; while disposable coin batteries capacity is much higher than that of rechargeable batteries, they seem to suffer from a limitation when it comes to current draw. Through our testing a 40mAH coin battery could power a 4mA constant current draw wearable for only 2-5 minutes. While a 17mAH rechargeable Lithium Ion Polymer battery could power the same wearable for 1 hour 30 minutes. Much attention should be paid to current draw when designing of ultralow power wearables as exceeding 5mA current draw will limit the choice of batteries and applications. To date, CR3023 coin batteries yields the best results and, depending on battery manufacturers, also yields the best battery effectiveness.

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