

Systemic Analysis of TENS Devices to Guide Future Design Improvements

Hamza Al Halabi, Mason Synk, Thomas Barnett

Problem Statement

The primary barrier to effective, long-term TENS therapy is the cumbersome, impractical, and problematic nature of the user interface.



Change/Innovation

The primary aspect of innovation that we as a group have settled on concerning the TENS unit is the integration of the TENS system directly into a comfortable, noninvasive wearable garment. This innovation is not merely an incremental improvement, but rather a direct, holistic response of the specific problems identified during our research into these devices.



Where We Are

There are some things that are on the market that are similar, but after a quick search there aren't any of them with this type of placement for the Tens unit. With this placement you can adjust the device and put it in a spot that is hands free and won't jostle around when move around. Currently we are thinking about a crop-top design to be able to put electrodes on the chest, upper back, traps, while being able to cover the shoulder. We also were thinking about the possibility of expanding to compensate for more muscle groups in the future.



- From the **Human** and **Mechanical** Systems perspective, a garment-based system directly solves the core usability problems of managing unwieldy wires, placing electrodes correctly, and carrying a bulky, separate container for the delicate insides of the device. It addresses the need for a truly ambulatory and ergonomic system that doesn't interfere with daily life, a key consideration in the original patent design (St. Louis and Caparso).
- From the **Biological** and **Electrical** Systems perspective, integrating electrodes into a garment using conductive textiles (Li et al.) ensures consistent and repeatable placement on the correct dermatomes. This could significantly improve therapeutic consistency and potentially mitigate the tolerance effect by ensuring the stimulation is always delivered to the optimal nerve pathways, addressing a key variable noted in the pain modulation research (Vera-Portocarrero et al.; Vance et al.).
- From the **Chemical** Systems perspective, our design direction allows us to sidestep the most problematic components of current TENS technology. By leveraging novel textile-based or dry electrodes (Al-Solihat et al.; Li et al.), we can move away from the cycle of applying, removing, and replacing disposable hydrogel electrodes, thereby eliminating the primary source of skin irritation and chemical degradation (Chatterjee and Inbarani; Lib-It and Ziv-Av).



Currently on the market

Acknowledgements

1. Li, Li & Man, Wai & Li, Yi & Wan, Kam & Wan, Sai & Wong, Thomas. (2010). Design of Intelligent Garment with Transcutaneous Electrical Nerve Stimulation Function Based on the Intarsia Knitting Technique. Textile Research Journal. 80. 279-286. 10.1177/0040517509105276.
2. St. Louis, Kevin, and Anthony V. Caparso. Implantable Pulse Generator and Method for Use with an Ambulatory Medical System. U.S. Patent 8,131,374 B2, filed 20 Apr. 2007, and issued 6 Mar. 2012.
3. Vance, C.G.T., et al. "Active-tDCS Applied to the Motor Cortex and Conditioned Pain Modulation in Healthy Individuals." Neuroscience Letters, vol. 705, 15 July 2019, pp. 200-06. ScienceDirect, doi:10.1016/j.neulet.2019.04.041.
4. Vera-Portocarrero, Louis P., et al. "Differential Effects of Subcutaneous vs. Transcutaneous Electrical Stimulation in Rodent Models of Inflammatory and Neuropathic Pain." Pain Medicine, vol. 15, no. 1, Jan. 2014, pp. 117-31. ScienceDirect, doi:10.1111/pme.12276.
5. Al-Solihat, Khaled M., et al. "Development of Novel, Flexible, and Biocompatible Ag/AgCl Dry Electrodes for Long-Term ECG Monitoring." Sensors, vol. 20, no. 15, 2020, p. 4104. MDPI, doi:10.3390/s20154104.
6. Celestin, M.M., et al. "Effects of a Novel Conductive Hydrogel on Skin Health and Electrostimulation Tolerance." Journal of Pain, vol. 14, no. 4, 2013, p. S73. ScienceDirect, doi:10.1016/j.jpain.2013.01.300.
7. Chatterjee, L. A., and P. G. Inbarani. "A Review on Skin-Compatible Medical Adhesives." Journal of Adhesion Science and Technology, vol. 33, no. 16, 2019, pp. 1735-1759. Taylor & Francis Online, doi:10.1080/01694243.2019.1614742.
8. Lib-It, David, and Ziv-Av, Amotz. Transcutaneous Electrical Nerve Stimulator Electrode Assembly. U.S. Patent 9,545,527 B2, filed 15 Oct. 2014, and issued 17 Jan. 2017.