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A Configurable Electro-Anesthesia Device

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Electro-anesthesia devices offer the ability to alleviate pain and maintain drug-induced anesthesia without re-administering drugs by passing a specially designed electrical current through the brain to sustain naturally or chemically produced endorphins. This potential extends the clinicians armamentarium for pain management, drug-addiction rehabilitation, and general anesthesia. This research focuses on the development of one such device which can be configured to use various waveforms for future electro-anesthesia studies.

There are several theories from renowned scientists worldwide which attempt to describe how the electro-anesthetic effect works. Although the phenomenon is not completely understood, studies have shown that a “packetized” waveform (called the Limoge waveform¹) (Figure 1) consisting of high- and low-frequency components passed through one electrode on the forehead and two on the mastoids (left and right respectively) (Figure 2) sustain an analgesic effect produced naturally during a period of excitement or by drugs such as morphine and Phenergan².

Such devices have been used to alleviate pain in wounded soldiers during the Vietnam War as an alternative to large doses of morphine³. Other experiments have shown positive results in weaning heroin addicts without using other interim narcotics⁴. Current studies using this technology show a decreased amount of self-administered intra-venous (IV) pain relievers in post-operative cancer patients⁵.

Unfortunately, true electro-anesthesia (inducing pre-operative sleep without drugs) has not been produced. The aforementioned examples all require some pre-existing high-level of endorphins or drugs plus the electro-anesthesia device to alleviate pain or sustain the anesthetic affect. This in part comes as a result of a lack of resources and the inability to test waveforms other than the Limoge waveform (for which the devices were exclusively designed) toward a more optimized effect.

We have designed a reconfigurable, inexpensive, high-speed digital arbitrary waveform generator with off-the-shelf components which will allow the exploration of other waveform types in future studies. The block diagram in Figure 3 gives an overview of the technology.

This device will allow us to create a multitude of waveform shapes which can be transmitted at varying frequencies and amplitudes. A waveform is first created in a program such as MATLAB. Once checked to assure the waveform is within specifications, it is uploaded to our device’s EEPROM where it is stored. Upon boot-up, the device loads the stored waveform into high-speed RAM and checks the validity of the data. Waveform transmission information (such as transmission rate and duration) may also be stored in the EEPROM.

Once a user issues a “RUN” command the device cycles through the data stored in RAM and sends it to a digital-to-analog converter (DAC). The analog signal is then amplified. A feedback

loop maintains the waveform current at a specified level. Safety interlocks protect against excessive voltage or current.

Our device recently underwent a re-design to allow for maximum flexibility pending new applications. We are currently completing hardware construction and writing the software to verify functionality. Unforeseen difficulties in amplifier design require us to leave the high-voltage/high-current amplifier stage as an add-on to be built in the next few months. We hope to have the waveform generation stage completed by the end of January. At that point, we intend to apply for a further grant and review of commercialization potential.

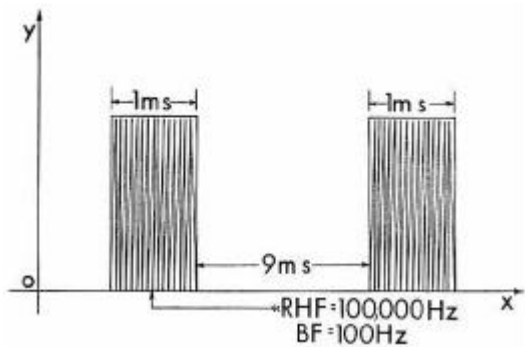


Figure 1 – The Limoge “packetized” waveform (Limoge p. 43)

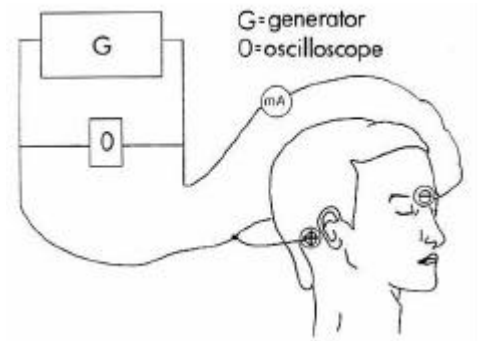


Figure 2 – Patient electrode placement (Limoge p. 54)

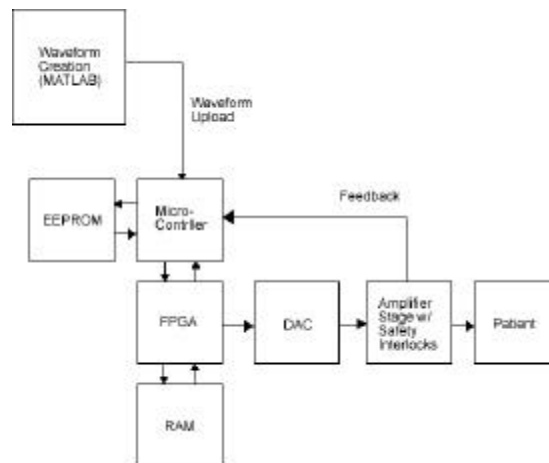


Figure 3 – Block diagram of high-speed digital arbitrary waveform generator.

¹ Named after Dr. Aimé Limoge who developed the modified waveform.

² These studies were performed by Dr. Aimé Limoge. Further information can be found in his book (see references)

³ Notes from an Electro-Anesthesia meeting with Dr. Limoge

⁴ Notes from an Electro-Anesthesia meeting with Dr. Limoge

⁵ Study being conducted with Dr. Limoge, Harding and Harris, Inc., and the Brain Instrumentation Lab at BYU.

References

A. Limoge. *An Introduction to Electroanesthesia*. Baltimore, Maryland:University Park Press, 1975