International Journal of Scientific Research Engineering & Technology (IJSRET)
Volume 1 Issue 5 pp 049-052 August 2012 www.ijsret.org ISSN 2278 – 0882

Neurostimulators Used in Brain for Parkinson's disease and Epilepsy Using Bionics

Shweta Gupta, Shashi Kumar Singh
Electronics and Communication Department
Dr. K.N. Modi University affiliated to Rajasthan University, District Tonk, Rajasthan
shwetagupta832000@gmail.com

ABSTRACT
This research paper present the development of device, which sends specific stimuli to different regions of brain for the patients of epilepsy and Parkinson' disease, who are resistant to drug treatment and those who suffer from tremors. It is a prime example of implementation of biomedical electronic solution that offers an enhancement to quality of life in someone afflicted with such conditions. It involves the use of neurostimulators, formed by the study of bionics, made to combat the fits of epilepsy. Similar to Cardiac Pacemaker, the deep brain stimulation (DBS) uses a neurostimulator to generate and deliver high frequency electric pulses into subthalmic nucleus (STN) or globus pallidus internus (GPi) portions of brain through extension wires and electrodes.

Keywords: *bionics, Parkinson's disease, epilepsy, Neurostimulators*

I. INTRODUCTION
Closed-loop deep brain stimulation (CDBS), for people with epilepsy, Parkinson's Disease (PD) or even obsessive compulsive disorder (OCD), is a prime example of implementation of a biomedical electronic solution that offers an enhancement to the quality of life in someone afflicted with such conditions. The DBS system detects a patient's electroencephalogram (EEG) and automatically generates DBS electrical pulses to prevent the onset of an epileptic seizure or even helps lessen the tremors of PD. DBS sends specific stimuli to different regions of the brain. DBS is used in patients who are resistant to drug treatment and those who suffer from motor fluctuations and tremors. To date only Medtronic has an FDA-approved DBS product.

Their bilateral DBSdevices, which were approved by FDA in 2002 consists of two neurostimulators, one for each side of brain.. The Medtronics Soletra neurostimulator is one of the most advanced battery-operated devices. The neurostimulator is typically programmed post-surgery by trained technicians to find the most effective signal parameters for alleviating Parkinson's symptoms. See Figure 1 for a simple block diagram of Medtronic's standard DBS product. We have used bionics which is an application of biological methods and systems found in nature to the study and design of engineering systems and modern technology. Examples of bionics in engineering include the hulls of boats imitating the thick skin of dolphins; sonar, radar, and medical ultrasound imaging imitating the echolocation of bats. In the field of computer science, the study of bionics has produced artificial neurons, artificial neural networks, and swarm intelligence. Thus the products of bionics are neurostimulators made to combat the fits of epilepsy and Parkinson's disease for the people who cannot take the medicines unknown. Early in the course of the disease, the most obvious symptoms are movement-related; these include shaking, rigidity, slowness of movement and difficulty with walking and gait. Later, cognitive and behavioral problems may arise, with dementia commonly occurring in the advanced stages of the disease. Other symptoms include sensory, sleep and emotional problems. Thus neurostimulator's are devised to overcome the above diseases. Known as Parkinson disease and epilepsy fits for people who can't take medicines.

A proposed basic design of a CDBS is as follows[1]: The CDBS device directly interfaces with recording and stimulation electrodes. Eight recording electrodes are implanted in the motor cortex and 64 stimulating electrodes are implanted in the STN portion of the brain. The 64-channel point-controllable stimulation enables the formation of various stimulus patterns for the most effective treatment of Parkinson's symptoms.

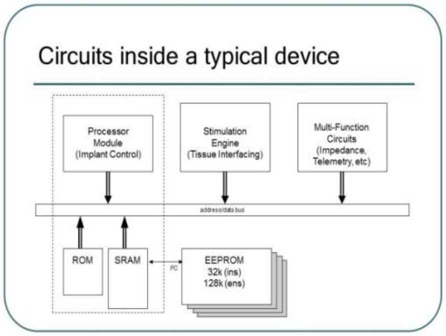

Fig. 1: Block diagram of the Medtronic deep brain stimulation system, which uses a neurostimulator to generate and deliver high-frequency electric pulses into portions of the brain. (Courtesy of Medtronics.)

The collected neural signals from the embedded microelectrodes should be conditioned using eight front-end low-noise neural amplifiers (LNAs). Due to the low-level amplitude of the neural spikes, integrated pre-amplifiers are sometimes used to amplify the small signals before the data conversion. The front-end design needs to be low noise to guarantee the signal integrity.

The front-end band-pass LNAs typically have a gain on the order of 100 and the LNA input design needs to minimize $1/f$ noise. A switched capacitor technique can be used for resistor emulation and $1/f$ noise reduction. The switched-capacitor circuit modulates the signal so that $1/f$ noise may be reduced to below thermal noise. The switched-capacitor amplifying filter performs well in recording neural spikes and field potential, simultaneously. The LNA's are in turn multiplexed to a single high-dynamic-range logarithmic amplifier front end into an analog-to-digital converter (ADC) making analog automatic gain control unnecessary.

To cover the entire range of both small-signal neural spikes and large-signal local field potential (LFP) responses from the brain stimulation, the high-dynamic-range ADC is needed to digitize all the desired neural information. The logarithmic amplifier, used in front of the ADC, is able to achieve this needed dynamic range. Logarithmic encoding is well-suited to neural signals and is efficient, since a large dynamic range can be represented with a short word length. To save area and power consumption, the relatively large-dynamic-range ADC is used, making analog automatic gain control unnecessary.

The ADC needs a digital filter which separates the low frequency neural field potential signal from the neural spike energy. Separation of the low-frequency field potential from the higher frequency spike energy can be done with a 22-tap finite-impulse-response (FIR) Butterworth-type digital filter. Using digital filters instead of analog or mixed-signal filters provides many advantages. First of all, a digital filter is programmable so that its operation may be adjusted without modifying hardware while generally an analog filter may be changed only by modifying the design. A digital filter is used for diplexers to separate two frequency bands of spikes and LFPs. While analog filter circuits are subject to drift and are dependent on temperature, a digital filter does not suffer from these issues, and is extremely robust with respect to both time and temperature.

The electrical stimulator generates 64 channels of biphasic charge-balanced current stimulation. A dedicated controller generates these stimulation patterns via an I/O channel to control the 64 current-steering DACs. The 64 DACs can be formed as a cascade of a single shared 2-bit coarse current DAC and 64 individual bi-directional 4-bit fine DACs or other similar configuration.

The DAC has 48 possible current values. One can use a fine ADC and a polarity switch selects the positive or negative DAC output to achieve charge-balanced bi-phasic stimulation, helping to reduce the risk of long-term tissue damage. Figure 2 below is a single chip for the CDBS system[2] that when interfaced with a microprocessor gives a complete CDBS system. "A microprocessor gives information to the chip about where and how, and the chip takes care of the rest," says Michael Flynn, a leader of the project.

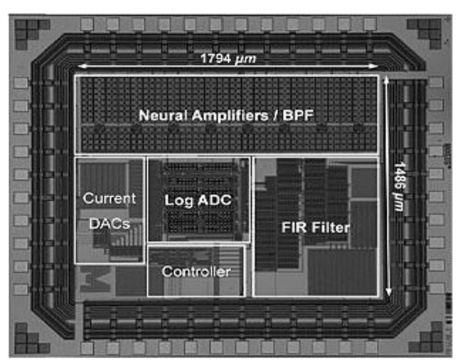

Fig 2: Typical closed-loop deep brain stimulation (CDBS) chip system block diagram (Courtesy of PHOTO: Michael Flynn & Daryl Kipke in article by

International Journal of Scientific Research Engineering & Technology (IJSRET)
Volume 1 Issue 5 pp 049-052 August 2012 www.ijsret.org ISSN 2278 – 0882

Morgen E. Peck, "A Chip to Better Control Brain Stimulators for Parkinson's" 2008).

In the medical electronics arena, Freescale has partnered with Cactus Semiconductor, which does custom analog design. Cactus Semiconductor's medical focus in integrated circuit design encompasses both implantable and portable applications such as neuro-stimulation, pacing, defibrillation, ultrasound, and medical monitoring (e.g., glucose meters). Freescale has suitable medical solutions with low-power microcontrollers, integrated analog front ends (AFEs) and algorithms that consume less power. Their wireless communication solutions assure low-power operating modes as well as good sleep modes with quick wake-up.

II. CONCLUSION

For the next generation of DBS and tools to help researchers understand the mystery of the brain, Medtronic is developing the Bi-directional Brain-machine interface[3] (BMI). This technique promises to be a major development tool in the frontier of brain research once all lab tests are completed and approved for use with human brain studies in the near future. Right now it is in preclinical research. There are no approved products yet.

Neurostimulation may reduce your chronic pain and improve your ability to go about your daily activities. Benefits may include:

- Significant and sustained reduction in chronic pain[1]
- Improved ability to function and participate in activities of daily living[1]
- Less oral pain medications
- Safe and effective
- Proven safe and effective when used as directed
- Tested in studies worldwide
- Reversible and non-destructive – the therapy can be turned off or surgically removed

In addition, this treatment:

- Can be adjusted to provide different levels of stimulation for various activities and times of day
- Lets you try the therapy for a short period of time before you receive a permanent implant

Neurostimulation Risks

The neurostimulation implant is surgically placed under the skin. Surgical complications are possible and may include infection, pain at the site of surgery, and bleeding into the epidural space. Once the neurostimulation system is implanted, device complications may occur and include corrective surgery, jolting, lead breaking, and movement of the lead within the epidural space which may require reprogramming or surgical replacement of the leads. These events may result in uncomfortable stimulation or loss of therapy.

As illustrated in the functional block diagram of Figure 3, the neural interface (NI) technology core is the existing stimulator and telemetry system found in released neurostimulators (Active by Medtronic).

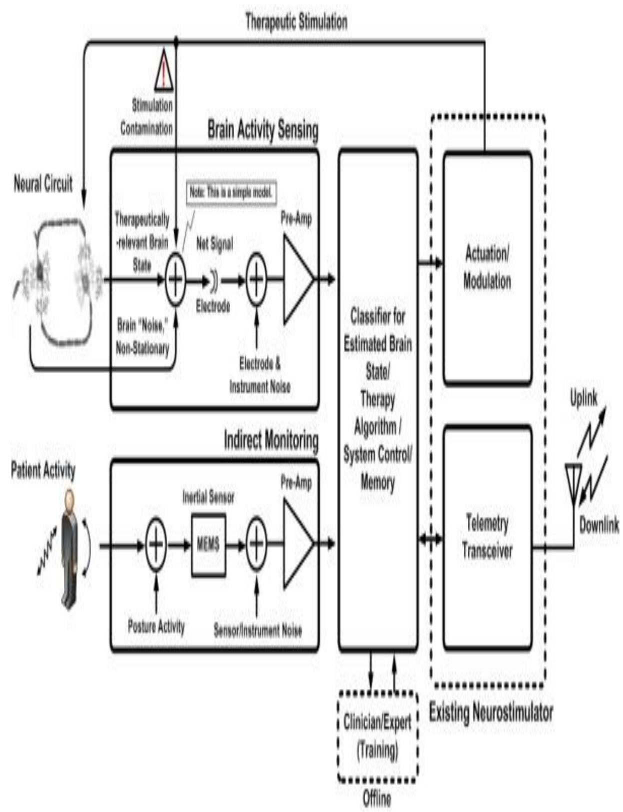

Fig 3: In this functional block diagram for a bi-directional neural interface system, the neural interface (NI) technology core is the existing stimulator and telemetry system found Inreleased neurostimulators (Courtesy of IOP publishing).

Referencing Fig. 4, the sensor hardware, algorithm processor and firmware partition are inserted into the existing infrastructure with well-defined signal pathways in the physical and algorithmic domains.

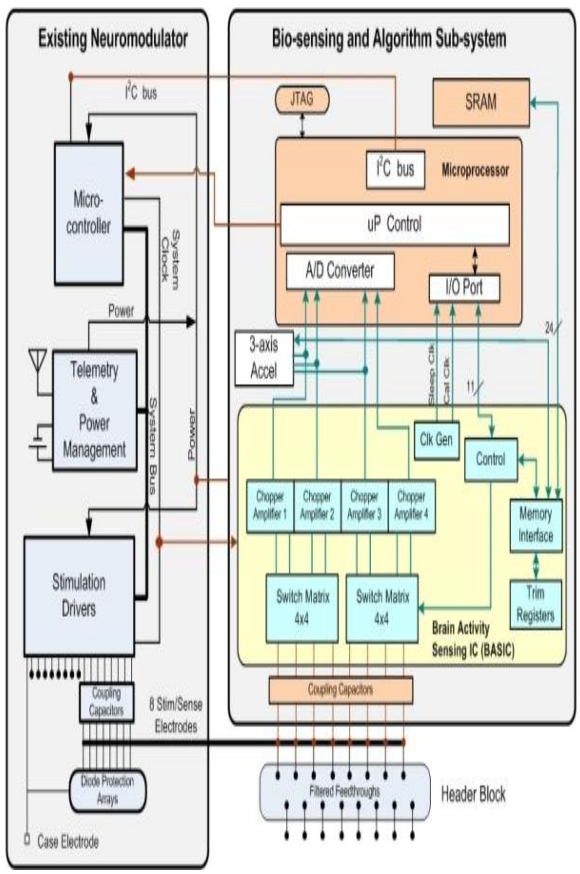

Fig 4: The sensor hardware, algorithm processor and firmware partition in the bi-directional brain-machine interface prototype are inserted into the existing infrastructure with well-defined signal pathways in the physical and algorithmic domains. (Courtesy of IOP publishing).

REFERENCES

[1] Benabid AL, Pollak P, Louveau A, Henry S, de Rougemont J. Combined (thalamotomy and stimulation) stereotactic surgery of the VIM thalamic nucleus for bilateral Parkinson's disease. Appl Neurophysiol 1987; 50: 344–6.

[2] Brown P, Oliviero A, Mazzone P, Insola A, Tonali P, Di Lazzaro V. Dopamine dependency of oscillations between subthalamic nucleus and pallidum in Parkinson's disease. J Neurosci 2001; 21: 1033–8.

[3] Krack P, Batir A, Van Blercom N, Chabardes S, Fraix V, Ardouin C, et al. Five-year-follow-up of bilateral stimulation of the subthalamic nucleus in advanced Parkinson's disease. N Engl J Med 2003; 349: 1925–34.

[4] Levy R, Ashby P, Hutchison WD, Lang AE, Lozano AM, Dostrovsky JO. Dependence of subthalamic nucleus oscillations on movement and dopamine in Parkinson's disease. Brain 2002; 125: 1196–209.

[5] Pollak P, Fraix V, Krack P, Moro E, Mendes A, Chabardes S, et al. Treatment results: Parkinson's disease. Mov Disord 2002; 17 Suppl 3: S75–83.

[6] Rodriguez-Oroz MC, Obeso JA, Lang AE, Houeto JL, Pollak P, Rehncrona S, et al. Bilateral deep brain stimulation in Parkinson's disease: a multicentre study with 4 years follow-up. Brain 2005; 128: 2240–9

[7] Tass PA. A model of desynchronizing deep brain stimulation with a demand-controlled coordinated reset of neural subpopulations. Biol Cybern 2003; 89: 81–8.

[8] Timmermann L, Gross J, Dirks M, Volkmann J, Freund HJ, Schnitzler A. The cerebral oscillatory network of parkinsonian resting tremor. Brain 2003; 126:199–212.

[9] Montgomery E B, Baker K B and Rezai A R 2001 *Effects of GPi stimulation on human thalamic neuronal activity Neuromodulation: defining the future* (The Cleveland Clinic Foundation, Cleveland, Ohio)

[10]Vitek J L, Bakay R A E, Hashimoto T, Kaneoke Y, Mewes K, Zhang J Y, Rye D B, Starr P, Baron M S, Turner R and DeLong M R 1998 *Microelectrode-guided pallidotomy: technical approach and application for treatment of medically intractable Parkinson's disease J. Neurosurg.***page**1027-43

[11] Yelnik J, Damier P, Bejjani B P, *et al* 2000 *Functional mapping of the human globus pallidus: contrasting effect of stimulation in the internal and external pallidum in Parkinson's disease Neurosciencepage page* 77-87

[12] Vitek J, Hashimoto T, Peoples J, DeLong M and Bakay R Acute 2004 *stimulation in the external segment of the globus pallidus improves parkinsonian motor signs Movement Disorders* pg. 907-15

[13] Vitek J L, Hashimoto T, Kaneoke Y, *et al* 1994 Improvement of parkinsonian motor signs during electrical stimulation of the pallidum *Movement Disorders* pg. 102

[14]Vitek J L, Ashe J, DeLong M R and Kaneoke Y 1996 Microstimulation of primate motor thalamus: somatotopic organization and differential distribution of evoked motor responses among subnuclei *J. Neurophysiol.* **75** 2486-95