

# NON INVASIVE DEEP BRAIN STIMULATION VIA TEMPORALLY INTERFERING ELECTRIC FIELD FOR PARKINSON'S DISEASE

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**ABSTRACT-** Over 7 to 10 million people worldwide are living with Parkinson's disease. Parkinson's disease cannot be cured, but its symptoms can be controlled by non-invasive DBS. A non-invasive strategy for electrically stimulating neurons at depth. By delivering to the brain multiple electric fields at frequencies too high to recruit neural firing, we can electrically stimulate neurons throughout a region where interference between the multiple fields results in a prominent electric field envelope modulated at the difference frequency. We validated this temporal interference (TI) concept via modelling. When two waves with slightly different frequencies meet, they will form an envelope wave whose frequency equals the difference of the frequencies of the two original waves. This phenomenon is known as temporal interference. This concept is exploited to achieve non-invasive DBS.

**KEY WORDS.** Transcranial electrical stimulation, Non-invasive DBS, temporal interference, brain stimulation, Parkinson's disease

## 1. INTRODUCTION

### 1.1. Parkinson's disease

Parkinson's disease (PD) is a long-term degenerative disorder of the central nervous system that mainly affects the motor system. It is caused due to the loss of nerve cells in the part of the brain called the substantia nigra. These cells produce dopamine, a chemical messenger responsible for transmitting signals within the brain that allow for coordination of movement. Loss of dopamine causes neurons to fire without normal control, leaving patients less able to direct or control their movement.

### 1.2. Symptoms

The most recognizable symptoms in Parkinson's disease are movement related. Non motor symptoms which include autonomic

dysfunction, neuropsychiatric problems (mood, cognition, behaviour or thought alterations), and sensory (especially altered sense of smell) and sleep difficulties, are also common. Non-motor symptoms, however, become increasingly common as the disease worsens. Early in the disease, the most obvious are shaking, rigidity, slowness of movement, difficulty with walking, Thinking and behavioural problems may also occur. Dementia becomes common in the advanced stages of the disease. Depression and anxiety are also common, occurring in more than a third of people with PD. The main motor symptoms are collectively called "parkinsonism", or a "parkinsonian syndrome". Four motor symptoms are considered cardinal in PD: tremor, slowness of movement (bradykinesia), rigidity, and postural instability.

### 1.3. Treatment

Parkinson's disease is a neurodegenerative disorder which lasts life-long. It cannot be cured, but its symptoms can be controlled by two common treatments:

### 1.4. Medication:

The main families of drugs useful for treating motor symptoms are levodopa (always combined with a dopa decarboxylase inhibitor and sometimes also with a COMT inhibitor), dopamine agonists and MAO-B inhibitors.

### Surgical procedures

When oral medications are not enough to control symptoms, surgery procedures (such as pallidotomy, thalamotomy, DBS), subcutaneous waking day apomorphine infusion and enteral dopa pumps can be of use.

**Thalamotomy** destroys part of the thalamus to block the things that cause your tremors from reaching the muscles. **Pallidotomy** surgery destroys the Globus pallidus to make you feel better. This treatment can make you less rigid and

ease tremors, improve balance, and make it easier for you to move. Thalamotomy and pallidotomy surgeries happen less frequently because of the risk of serious side effects.

### Deep brain stimulation

Deep brain stimulation (DBS) is a neurosurgical procedure which requires open-skull surgery to place the electrode into the specific regions deep in the brain that control movement, such as the sub thalamic nucleus. After implantation, the electrode is connected to a battery-powered stimulator called neurostimulator that can precisely deliver a continuous electrical impulses, through implanted electrodes, to specific targets in the brain (brain nuclei) for the treatment of movement disorders, including Parkinson's disease, essential tremor, and dystonia. DBS directly changes brain activity in a controlled manner. It has been approved by the US Food and Drug Administration for PD and essential tremor. While DBS is generally safe and has proven to be effective for some people, the potential for serious complications and side effects exists. First and foremost, it is highly invasive, requiring small holes to be drilled in the patient's skull, through which the electrodes are inserted. Potential complications of this include infection, stroke, and bleeding on the brain. The electrodes, which are implanted for long periods of time, sometimes move out of place; they can also cause swelling at the implantation site; and the wire connecting them to the battery, typically placed under the skin of the chest, can erode, all of which require additional surgical procedures.

### Non invasive DBS

To avoid these complications "Non -invasive Deep Brain Stimulation via Temporally Interfering Electrical Fields" which describes a non -surgical technique that achieves an effect similar to that of invasive DBS. In which the electrodes are placed on the scalp, by taking advantage of a phenomenon known as temporal interface. This strategy requires generating two high-frequency electrical currents using electrodes placed outside the brain. These fields are too fast to drive neurons. However, these currents interfere with one another in such a way that where they intersect, deep in the brain, small region of low-frequency current is generated inside neurons, this low-frequency current can be used to drive neurons electrical activity, while the high-frequency current passes through surrounding tissues with no effect. Non-invasive DBS can be used for patients with PD of at least 4 years duration and 4 month of motor complications and can improve tremor, rigidity, slowness.

### 1.5. Need for the project

DBS is generally safe but, like any surgical procedure, comes with some risks. Most notably; the electrodes are implanted via invasive open-skull surgery

that can lead to various complications. For example, the rate of DBS-related infection has been reported to range from 3.8% to 12.6%. The rigid electrodes might move out of place and cause further damage to the brain. Lastly, scar tissue accumulated around the electrodes can decrease the efficacy of stimulation treatment over time. But the non invasive DBS method was safe with no signs of cell death, DNA damage, increased tissue temperature, or seizure risk.

## 2. LITERATURE SURVEY

### Introduction

This chapter deals with the literature survey of Parkinson's disease, diagnosis of Parkinson's disease. This chapter also describes the literature survey on Deep Brain Stimulation and Non-invasive DBS. From the elaborated literature survey the motivation for the present work is presented.

### 2.1. Literature survey on Parkinson's disease and its diagnosis

Parkinson's disease (PD) is a progressive neurological disorder characterised by a large number of motor and non-motor features that can impact on function to a variable degree. This review describes the clinical characteristics of PD with emphasis on those features that differentiate the disease from other parkinsonian disorders. There is no definitive test for the diagnosis of PD, the disease must be diagnosed based on clinical criteria. Rest tremor, bradykinesia, rigidity and loss of postural reflexes are generally considered the cardinal signs of PD. The presence and specific presentation of these features are used to differentiate PD from related parkinsonian disorders. Other clinical features include secondary motor symptoms, non-motor symptoms.

Aarushi Agarwal proposed et al , (2016) IEEE International conference on the Prediction of Parkinson's disease using speech signal with Extreme Learning Machine described an Speech impairments analysis has been used as an efficient tool for early detection of Parkinson's disease (PD). In this paper, we have proposed an efficient approach using Extreme Learning Machine to predict Parkinson's disease accurately utilising speech samples. The performance of the method has been assessed with a reliable dataset from UCI repository. The proposed method distinguishes Parkinson diseased subjects and healthy subjects with an accuracy of 90.76% and 0.81 MCC for the training dataset. When tested with an independent dataset comprising of Parkinson diseased patients, the proposed method gives 81.55% accuracy. The performance of our method is compared with existing techniques such as Neural Network and Support Vector

Machine. The results obtained depict that the proffered method is reliable for identifying the Parkinson's disease.

R. Viswanathan, P. Khojasteh, (2018) IEEE International conference on Efficiency of Voice Features based on Consonant for Detection of Parkinson's Disease described on the efficiency of features extracted from sustained voiced consonant in the diagnosis of Parkinson's disease (PD). The diagnostics applicability of the phonation /m/ is also compared with that of sustained phonation, the one which is commonly employed in PD speech studies. The study included 40 subjects out of which 18 were PD and 22 were controls. The features extracted were used in SVM classifier model to differentiate PD and healthy subjects. The phonation yielded classification accuracy of 93% and Matthews Correlation Coefficient (MCC) of 0.85 while the classification accuracy for phonation was 70% and MCC of 0.39. The spearman correlation coefficient analysis also showed that the features from /m/ phonation were highly correlated with the Unified Parkinson's Disease Rating Scale (UPDRS-III) motor score. The results suggest the applicability of features corresponding to nasal consonant in the diagnosis and progression monitoring of PD

## 2.2. Literature survey on deep brain stimulation

Todd M. Herrington, Jennifer J. Cheng and Emad N. Eskandar, (2016) Journal of neurophysiology deals with Deep Brain Stimulation (DBS) is the therapeutic use of chronic electrical stimulation of the brain via an implanted electrode. It is most commonly used to treat the motor symptoms of Parkinson's disease (PD), essential tremor, and dystonia, and it is in more limited use or under active investigation to treat a wide variety of neurological and psychiatric conditions including epilepsy, obsessive-compulsive disorder, and major depression. The most commonly used DBS system uses a four-contact stimulating electrode stereo tactically implanted in the target and connected via a subcutaneous wire to a pacemaker-like unit called an implantable pulse generator (IPG) that is placed on the chest wall underneath the collarbone. Electrodes are typically placed bilaterally, although clinical needs sometimes dictate unilateral stimulation. Most targets are deep brain structures (including deep white matter tracts) rather than cortical areas. A clinician uses a handheld device to wirelessly communicate with the IPG to adjust the parameters of stimulation, tuning stimulation to maximize symptom relief and minimize side effects.

Little S, Beudel M, Zrinzo L, et al, (2016) Journal of Neurology Neurosurgery and Psychiatry described as Bilateral adaptive deep brain stimulation is effective in

Parkinson's disease described as Deep brain stimulation (DBS) is an established treatment for advanced Parkinson's disease (PD). However, its applicability is limited by costs, side effects and partial efficacy. That symptoms fluctuate based on cognitive/motor load, stress and medication status in PD is well established. Increasing evidence suggests that these fluctuations are associated with varying levels of sub cortical  $\beta$  (13–30 Hz) oscillations, changes in the amplitude of which correlate with motor improvement in response to treatment. Building on a pioneering adaptive DBS (aDBS) study in the parkinsonian non-human primate, we recently successfully applied a DBS to patients with PD by triggering stimulation off the amplitude of  $\beta$  activity in the local field potential recorded from the sub thalamic nucleus. This study showed that aDBS was more effective than continuous DBS (cDBS) despite <50% of the total time on stimulation.

## 2.3. Literature survey on non invasive deep brain stimulation

Grossman et al, (2017) Cell 169, Elsevier Inc described on Non-invasive Deep Brain Stimulation via Temporally Interfering Electric Fields report a non-invasive strategy for electrically stimulating neurons at depth. By delivering to the brain multiple electric fields at frequencies too high to recruit neural firing, but which differ by a frequency within the dynamic range of neural firing, can electrically stimulate neurons throughout a region where interference between the multiple field results in a prominent electric field envelope modulated at the difference frequency. They validated this temporal interference (TI) concept via modelling and physics experiments, and verified that neurons in the living mouse brain could follow the electric field envelope. They demonstrate the utility of TI stimulation by stimulating neurons in the hippocampus of living mice without recruiting neurons of the overlying cortex. Finally, they show that by altering the currents delivered to a set of immobile electrodes, can steerable evoke different motor patterns in living mice.

Jacek Dmochowski and Marom Bikson, (2017) Cell 169, Elsevier Inc described on Electromagnetic approaches such as transcranial magnetic stimulation and transcranial direct current stimulation is at the forefront. One seemingly unavoidable limitation of these and other electromagnetic techniques is the inability to target deep brain regions. With non-invasive stimulation, the intensity of electromagnetic fields drops off with distance from the surface of the head, meaning that superficial brain areas are activated first. In this issue of Cell, a long-standing acoustical phenomenon to propose a form of non-invasive electrical brain stimulation capable of stimulating deep brain areas in a selective manner: "temporal interference" (TI) stimulation. When two tones of similar frequency are simultaneously emitted, the envelope of the net signal oscillates at a low frequency equal to the difference of the

two tones, known as the “beat frequency.” The underlying assumption of TI stimulation is that neurons are unresponsive to high-frequency stimulation with a flat envelope, while neurons will respond to the “beating” high-frequency stimulation, leading to selective stimulation of neurons in the intermediate (i.e., deep) brain region.

### 3. METHODOLOGY

#### 3.1. Software used

##### LabVIEW

**Laboratory Virtual Instrument Engineering Workbench (LabVIEW)** is a system-design platform and development environment for a visual programming language from National Instruments. The graphical language is named "G"; not to be confused with G-code. Originally released for the Apple Macintosh in 1986, LabVIEW is commonly used for data acquisition, instrument control, and industrial automation on a variety of operating systems (OSs), including Microsoft Windows, various versions of Unix, Linux, and macOS. The latest versions of LabVIEW are LabVIEW 2018 and LabVIEW NXG 3.0, released in November 2018.

##### Data flow programming

The programming paradigm used in LabVIEW, sometimes called G, is based on data availability. Execution flow is determined by the structure of a graphical block diagram (the LabVIEW-source code) on which the programmer connects different function-nodes by drawing wires. These wires propagate variables and any node can execute as soon as all its input data become available.

##### Graphical programming

LabVIEW programs-subroutines are termed virtual instruments (VIs). Each VI has three components: a block diagram, a front panel, and a connector panel. The front panel is built using controls and indicators. Controls are inputs. Indicators are outputs. The back panel, which is a block diagram, contains the graphical source code. The back panel also contains structures and functions which perform operations on controls and supply data to indicators. Collectively controls, indicators, structures, and functions are referred to as nodes. Nodes are connected to one another using wires.

##### SKETCHUP

SketchUp, formerly Google SketchUp, is a 3D modelling computer program for a wide range of drawing applications such as architectural, interior design, landscape architecture, civil and mechanical engineering, film and video game design. It is available as a web-based

application. Original author –@Last software GOGGLE. It was introduced by last software in August 2000 over 19 years ago. It is available in both 32 bit and 64 bit for users and also for macOS users.

##### 3D WAREHOUSE

3D Warehouse is an open library in which SketchUp users may upload and download 3D models to share. The models can be downloaded right into the program without anything having to be saved onto your computer's storage. File sizes of the models can be up to 50 MB. Anyone can make, modify and re-upload content to and from the 3D warehouse free of charge. All the models in 3D Warehouse are free, so anyone can download files for use in SketchUp

##### V-Ray

**V-Ray** is a computer-generated imagery rendering software application developed by the Bulgarian company Chaos Group, that was established in Sofia in 1997. V-Ray is a commercial plug-in for third-party 3D computer graphics software applications and is used for visualizations and computer graphics in industries such as media, entertainment, film and video game production, industrial design, product design and architecture. Chaos group developed in 1997 over 22 years ago for rendering system. V-Ray is a rendering engine that uses global illumination algorithms, including path tracing, photon mapping, and irradiance maps and directly computed global illumination. The desktop 3D applications that are supported by V-Ray are Autodesk 3ds Max, Autodesk Revit, Cinema 4D, Maya, Modo, Nuke, Rhinoceros, SketchUp, Softimage, Blender. Here we used SketchUp for 3D visualization and that can be applied to the V-Ray software for rendering process.

#### 3.2. Block diagram

The proposed method is designed to provide solution for the control of motor symptoms of Parkinson's disease. The block diagram for proposed method is shown in table 3.1. The description of each block is explained below.

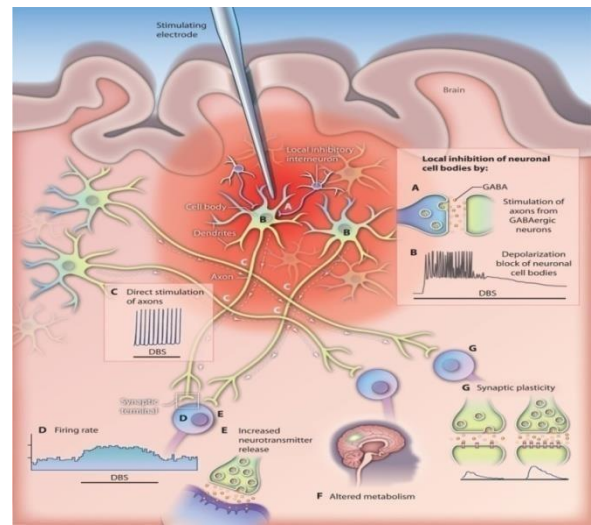
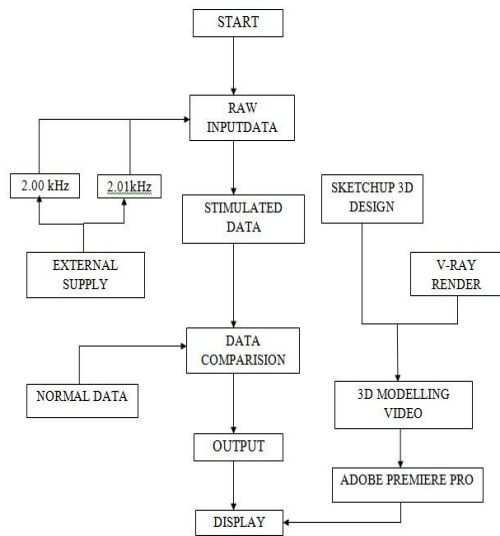


Fig- 2: Internal process of stimulation

**Non invasive DBS**

The non-invasive Deep Brain Stimulation does not require any surgeries and can achieve an affect similar to that of DBS. This method is based on the phenomenon of temporal interference. The temporal interference of electrical signal was demonstrated by using labview.

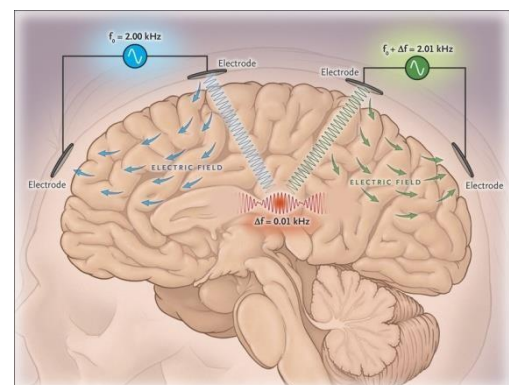


Fig- 3: Non invasive deep brain stimulation

**Invasive DBS**

The Parkinson’s disease symptoms can be controlled by invasive deep brain stimulation or electrode stimulation treatment, in which a open skull surgery is done to place the electrode into the specific regions deep in the brain that control movement, such as subthalamic nucleus. After implantation, the electrode is connected to battery-powered stimulator that can precisely deliver a continuous flow of electricity. This electrical current controls how neurons communicate with each other.

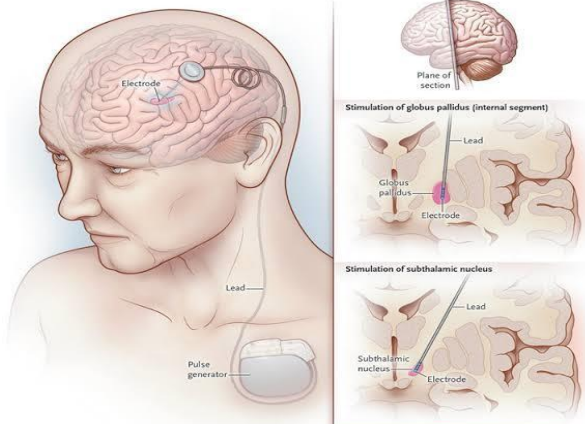


Fig- 1: Invasive deep brain stimulation

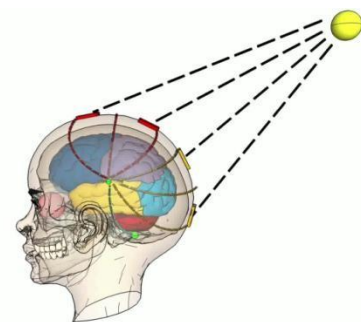


Fig- 4: Non invasive deep brain stimulation

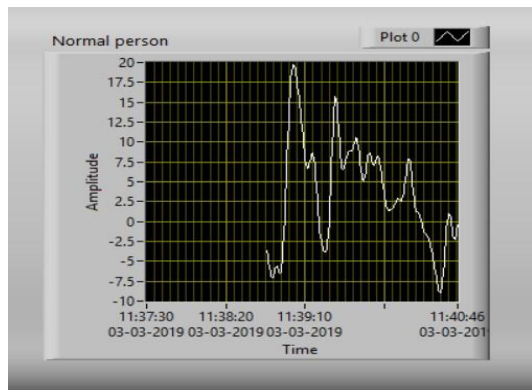
**B. Process**

**Normal EEG**

The normal EEG values obtained from the physionet are converted into waveform by using waveform charts.

**Table 1- normal EEG values**

S.NO	NORMAL VALUES
1	8.648
2	8.236
3	9.954
4	7.704
5	10.216
6	12.484
7	11.619
8	8.516
9	9.215
10	9.157



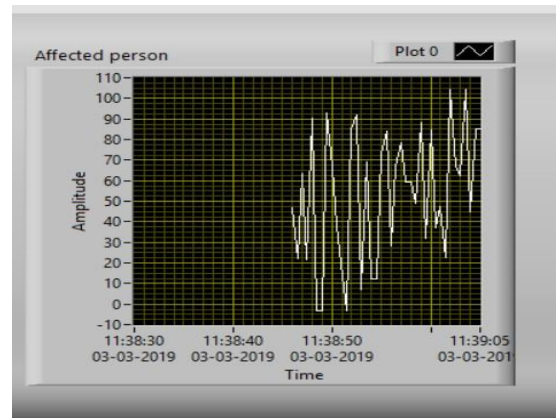
**Fig- 5: Normal EEG generated wave**

**Abnormal EEG**

The abnormal EEG values of a patient with Parkinson’s disease are taken from the physionet and it’s also converted into waveforms by using waveform charts.

**Table 3-Abnormal EEG values**

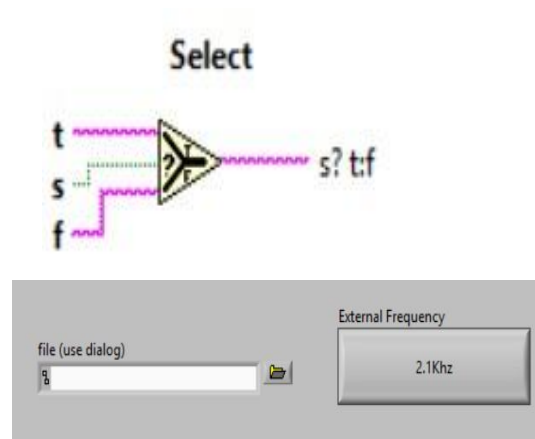
S.NO	ABNORMAL VALUES
1	-3.145
2	-4.568
3	-11.356
4	-5.789
5	-2.102
6	-0.548
7	1.259
8	0.548
9	-2.784
10	1.074



**Fig- 6: Abnormal EEG wave**

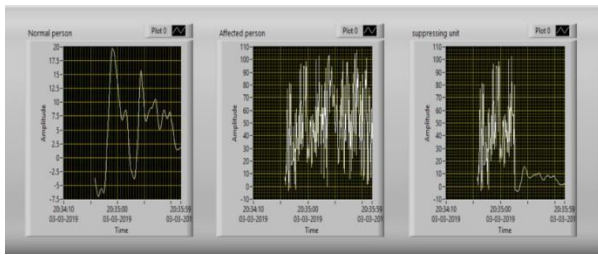
**External supply**

An external stimulation of 10Hz was developed by interfering two electrical fields 2.00 kHz and 2.10 kHz which form an envelope of 10 Hz (difference between two fields) by using select function in a lab view.



**Fig- 7: Select function**

The abnormal EEG waves are stimulated by the external frequency of 10Hz. The stimulated waves are compared with the normal EEG waves.



**Fig- 8: stimulated EEG waves compared with normal EEG waves.**

When the output wave is similar to normal EEG waves. Thus the output is verified and displayed by using Labview software.

### 3.3. LabVIEW components

#### File path

#### String controls and indicators

Right-click a string control or indicator to change the string display type and behavior, such as password display or hex display. You can also use VIs and functions from the File I/O palette to pass strings to an external file, such as a text file or spreadsheet

#### Numeric controls and indicators

Use numeric controls and indicators on the front panel to enter and display numeric data in LabVIEW applications. The following list describes the common use cases of numeric controls and indicators available on the Modern, Silver, System, or Classic subpalettes.

#### XY Graph

The XY graph is a general-purpose, Cartesian graphing object that plots multivalued functions, such as circular shapes or waveforms with a varying time base. The XY graph displays any set of points, evenly sampled or not. You also can display Nyquist planes, Nichols planes, S planes, and Z planes on the XY graph. Lines and labels on these planes are the same color as the Cartesian lines, and you cannot modify the plane label font.

#### Spreadsheet string to array function

Converts the spreadsheet string to an array of the dimension and representation of array type. This function works for arrays of strings and arrays of numbers. The connector pane displays the default data types for this polymorphic function.

#### Build array function

Concatenates multiple arrays or appends elements to an n-dimensional array. You also can use the Replace

Array Subset function to modify an existing array. The connector pane displays the default data types for this polymorphic function

#### Output

Complete the following steps to create a multicolumn listbox.

1. Add the multicolumn listbox control to the front panel window.
2. To add an option item, use the Labeling tool to type in a cell in the leftmost column.
3. Type in the cells in the same row to add information about each option item.
4. (Optional) set the selection mode of a multicolumn listbox.
5. (Optional) Change the color of the symbols and the color of the headers and cells.

You also can add header text to a multicolumn listbox, show and hide multicolumn listbox headers, and add rows and columns to a multicolumn listbox.

#### Waveform charts

The waveform chart is a special type of numeric indicator that displays one or more plots of data typically acquired at a constant rate. The following front panel shows an example of a waveform chart. The waveform chart maintains a history of data, or buffer, from previous updates. Right-click the chart and select Chart History Length from the shortcut menu to configure the buffer. The default chart history length for a waveform chart is 1,024 data points. The frequency at which you send data to the chart determines how often the chart redraws

#### Get date/time in seconds function

Timer resolution is system dependent and might be less accurate than one millisecond, depending on your platform. When you perform timing, use the Tick Count (ms) function to improve resolution

#### For loop

Executes its subdiagram n times, where n is the value wired to the count (N) terminal. The iteration (i) terminal provides the current loop iteration count, which ranges from 0 to n-1.

#### Boolean controls and indicators

Use Boolean controls and indicators located on the Boolean subpalettes to enter and display Boolean (TRUE/FALSE) values with objects such as buttons,

switches, and LED lights. The following list describes the common use cases of Boolean controls and indicators available on the Modern, Silver, System, or Classic subpalettes

**Select function**

Returns the value wired to the t input or f input, depending on the value of s. If s is TRUE, this function returns the value wired to t. If s is FALSE, this function returns the value wired to f. The connector pane displays the default data types for this polymorphic function

**Wait ms function**

Waits the specified number of milliseconds and returns the value of the millisecond timer. Wiring a value of 0 to the milliseconds to wait input forces the current thread to yield control of the CPU. This function makes asynchronous system calls, but the nodes themselves function synchronously. Therefore, it does not complete execution until the specified time has elapsed

**Number to fractional function**

Converts number to an F-format (fractional notation), floating-point string at least width characters wide or wider if necessary. The connector pane displays the default data types for this polymorphic function.

**Random number (0-n) function**

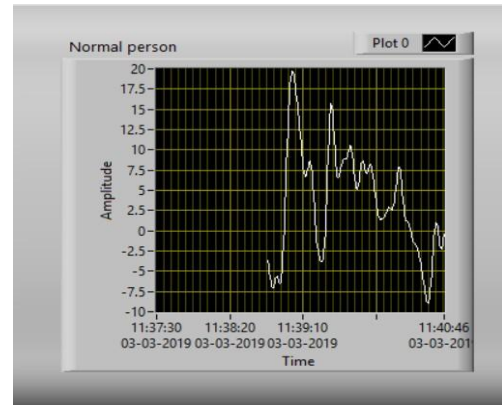
Produces a double-precision, floating-point number between 0 and 1. The number generated is greater than or equal to 0, but less than 1. The distribution is uniform. Alternatively, you can use several of the Signal Generation VIs or the Signal Generation PtByPt VIs to regenerate the same random sequence. For example, the Uniform White Noise VI allows you to set a seed number that you can use to initialize the generation of a pseudorandom pattern

**4. RESULT & DISCUSSION**

**4.1. Input data**

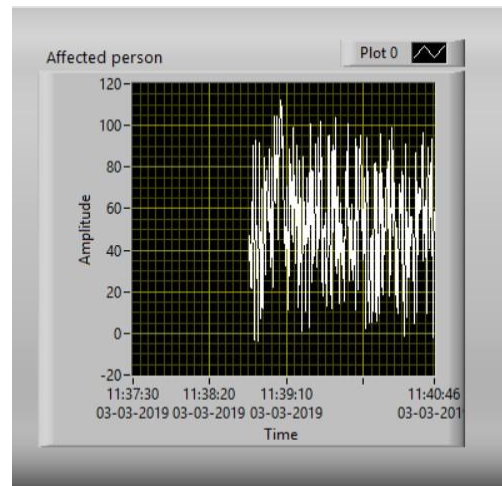
**Before stimulation**

Graphical representation of the normal value which was taken from the physionet.



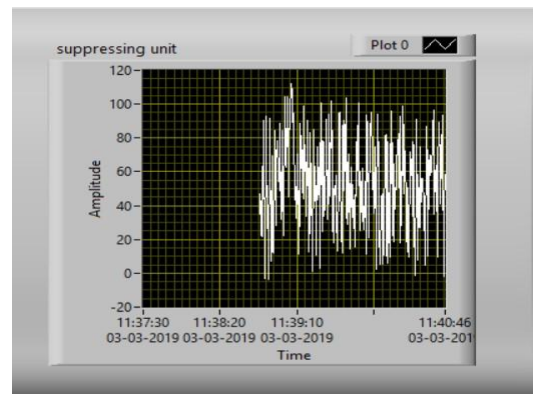
**Fig- 9: the normal EEG waves**

Graphical representation of the abnormal value which was taken from the physionet.



**Fig- 10: Abnormal EEG waves**

This is the graphical representation of the suppressing unit through which we can differentiate the variation between the stimulated and non stimulated eeg waves.



**Fig- 11: before stimulating the abnormal EEG waves**

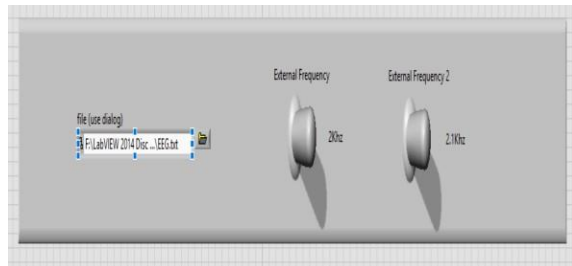


**B. Input value representation**

Time	Date	Normal Person	Affected person	External Frequency	Suppressed O/P
14:18:47	16-03-2019	-3.648000	11.602000	No requery	11.602000
14:18:48	16-03-2019	-4.236000	81.323853	No requery	81.323853
14:18:48	16-03-2019	-4.954000	31.692904	No requery	31.692904
14:18:49	16-03-2019	-5.704000	24.835309	No requery	24.835309
14:18:49	16-03-2019	-6.370000	7.821318	No requery	7.821318
14:18:50	16-03-2019	-6.847000	91.029428	No requery	91.029428
14:18:50	16-03-2019	-7.067000	79.034176	No requery	79.034176
14:18:51	16-03-2019	-7.024000	6.091013	No requery	6.091013
14:18:51	16-03-2019	-6.767000	7.597953	No requery	7.597953
14:18:52	16-03-2019	-6.391000	12.397775	No requery	12.397775
14:18:52	16-03-2019	-6.015000	-0.045918	No requery	-0.045918
14:18:53	16-03-2019	-5.747000	5.435910	No requery	5.435910
14:18:53	16-03-2019	-5.662000	38.829067	No requery	38.829067
14:18:54	16-03-2019	-5.775000	79.436429	No requery	79.436429
14:18:54	16-03-2019	-6.034000	60.324173	No requery	60.324173
14:18:55	16-03-2019	-6.321000	33.755683	No requery	33.755683
14:18:55	16-03-2019	-6.489000	34.461745	No requery	34.461745
14:18:56	16-03-2019	-6.366000	13.428496	No requery	13.428496
14:18:56	16-03-2019	-5.839000	36.317399	No requery	36.317399
14:18:57	16-03-2019	-4.844000	73.484940	No requery	73.484940
14:18:57	16-03-2019	-3.886000	9.950743	No requery	9.950743
14:18:58	16-03-2019	-1.531000	49.937483	No requery	49.937483
14:18:58	16-03-2019	0.619000	9.598490	No requery	9.598490
14:18:59	16-03-2019	2.955000	39.757373	No requery	39.757373
14:18:59	16-03-2019	5.385000	59.694977	No requery	59.694977
14:19:00	16-03-2019	7.828000	102.728222	No requery	102.728222
14:19:00	16-03-2019	10.216000	52.296272	No requery	52.296272

**Fig-12: before applying frequency of 10 Hz**

These are the value which represents the non suppressing unit for our convenience. Because through the graph we cannot able to predict the accurate values of the waveform.



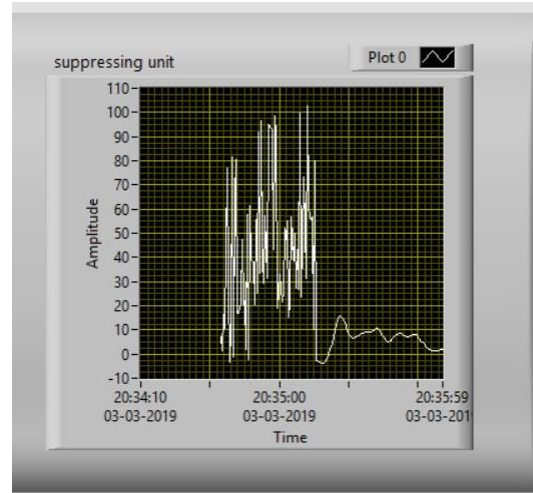
**Fig- 13: External frequency supply**

To stimulate the given abnormal waveform in our work we use the external frequencies over 10hz differences to achieve this condition this external frequency port is used.

Time	Date	Normal Person	Affected person	External Frequency	Suppressed O/P
14:25:01	16-03-2019	2.196000	5.377699	No requery	5.377699
14:25:01	16-03-2019	2.148000	9.653486	No requery	9.653486
14:25:02	16-03-2019	2.319000	24.451871	No requery	24.451871
14:25:02	16-03-2019	2.743000	83.088066	No requery	83.088066
14:25:03	16-03-2019	3.373000	12.031429	No requery	12.031429
14:25:03	16-03-2019	4.110000	58.085574	No requery	58.085574
14:25:04	16-03-2019	4.833000	5.560393	No requery	5.560393
14:25:04	16-03-2019	5.440000	34.967509	No requery	34.967509
14:25:05	16-03-2019	5.884000	74.226311	10KHz Freq passed	6.157548
14:25:05	16-03-2019	6.158000	49.786639	10KHz Freq passed	6.990448
14:25:06	16-03-2019	6.287000	90.704010	10KHz Freq passed	7.212059
14:25:06	16-03-2019	6.297000	10.048229	10KHz Freq passed	7.062886
14:25:07	16-03-2019	6.195000	43.265124	10KHz Freq passed	6.508588
14:25:07	16-03-2019	5.960000	83.798501	10KHz Freq passed	6.877479
14:25:08	16-03-2019	5.573000	66.145727	10KHz Freq passed	5.723757
14:25:08	16-03-2019	5.023000	30.233661	10KHz Freq passed	5.543200
14:25:09	16-03-2019	4.329000	96.693932	10KHz Freq passed	4.535720
14:25:09	16-03-2019	3.531000	17.156270	10KHz Freq passed	3.925769
14:25:10	16-03-2019	2.705000	70.858932	10KHz Freq passed	3.247988
14:25:10	16-03-2019	1.916000	94.973008	10KHz Freq passed	2.658703
14:25:11	16-03-2019	1.222000	4.090730	10KHz Freq passed	1.675497
14:25:11	16-03-2019	0.671000	30.241928	10KHz Freq passed	1.412555
14:25:12	16-03-2019	0.303000	82.893146	10KHz Freq passed	1.041764
14:25:12	16-03-2019	0.142000	15.190748	10KHz Freq passed	0.817406
14:25:13	16-03-2019	0.196000	70.045753	10KHz Freq passed	0.398086
14:25:13	16-03-2019	0.434000	62.978485	10KHz Freq passed	0.405121
14:25:14	16-03-2019	0.785000	70.102350	10KHz Freq passed	1.295637
14:25:14	16-03-2019	1.128000	92.954962	10KHz Freq passed	1.797328
14:25:15	16-03-2019	1.317000	78.851432	10KHz Freq passed	2.201665

**Fig-14: values after applying external frequency of 10 Hz**

These are list of values which represents the stimulated values that are moreover equal to the normal values and converted to the values from the normal graph.



**Fig -15:the suppressed output**

These are the graphical representation of the waveform which is commonly an abnormal waveform stimulated by applying external frequency.

**5. CONCLUSION & FUTURE WORK**

**5.1. Conclusion**

This method of temporal interference stimulation, applies multiple electric fields of different frequencies at once; when combined, it produce a single signal that can be targeted to specific deep brain regions. By themselves, changing electrical currents are too rapid to recruit neural activity, but at the small regions where the currents intersect, the amplitude, of their combined currents changes at a low frequency that is capable of stimulating the neural activity. While other non-surgical brain stimulation methods are already being assessed in human clinical trials, non-invasive DBS has the advantage of stimulating only specific targeted neurons without affecting the activity of their neighbours or overlying regions.

Non-invasive DBS for Parkinson's disease offers multitude of benefits, from increased control to reduced medication. It may prolong life for Parkinson's patients.

**5.2. Future work**

It can be used to treat parkinsonian patient of above 60 years. Non-invasive DBS offers an effective hope for people suffering from neurological and neuropsychiatric disorders. Large numbers of electrodes and multiple sets of interfering fields may be able to target

smaller regions of the brain; which is the region that's targeted when treating Parkinson's disease.

## 6. REFERENCES

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