Application Software

Short Manual

BIC Evaluation Kit

CorTec GmbH
Neuer Messplatz 3
79108 Freiburg
Germany

Version: 2020-08-06

1. Content

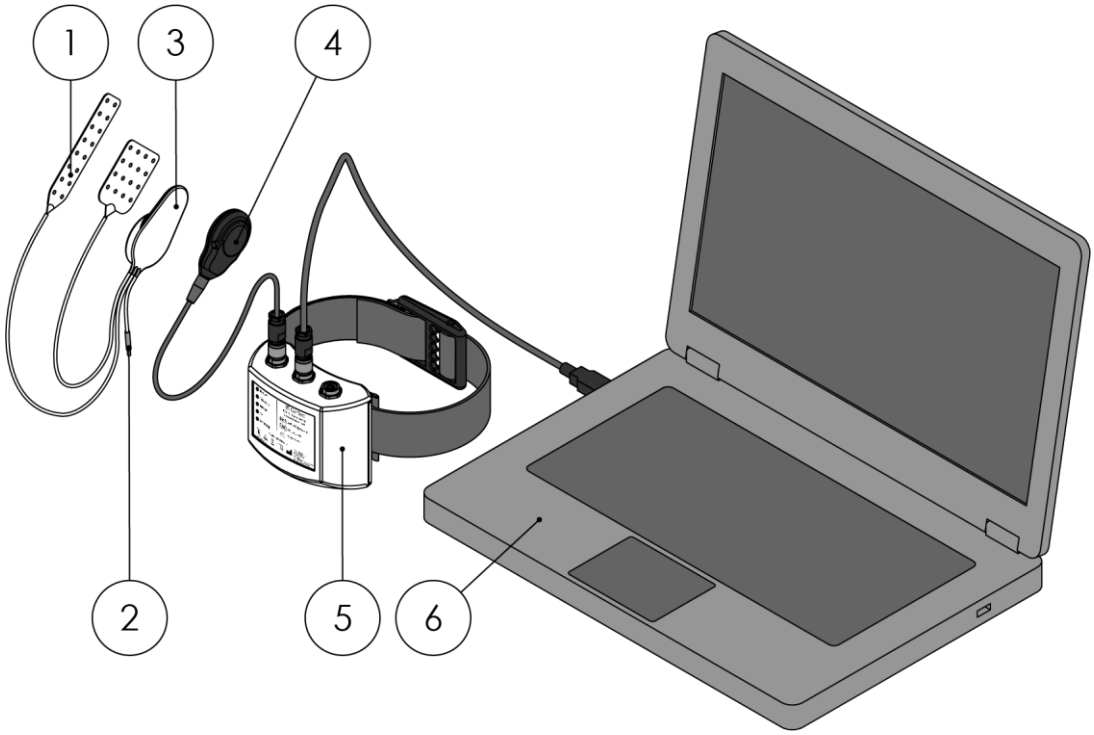
2. Information

Table 1: Information

Topic	Information	
Manual Version:	2020-07-09	
Author:	M. Schuettler	
Reviewed:	C. Stolle	
Software Releases: (Screenshots):	Implant firmware: Launcher: Implant plugin: Other plugins:	1.0.121.23885 trunk 1.0.121.21777 trunk 1.0.121.24030 trunk 1.0.121.21449 trunk

3. System Description

The Brain Interchange (BIC) system consists of Implanted Grid Electrodes connected to an Implanted Electronic Unit. The Implanted Electronic Unit is wirelessly powered from outside the body by a Head Piece and communicates wirelessly to a Communication Unit. The Communication Unit relays information (e.g. neural data and status information) from the implant to a laptop as well as transfers commands (e.g. electrical stimulation commands) from the laptop to the implant. Figure 1 illustrates the main components the system consists of.
The Application Software runs on the Personal Computer (Figure 1, No 6) and offers the control of the implant and gathering of implant data using a graphical user interface.



1: Electrode Model Module
2: Electrode Connector
3: Implant Module
4: Head Piece
5: Communication Unit
A - Head Piece Cable Connector
B - USB Cable Connector
C - Trigger Input Connector
6: Personal Computer

Figure 1: Overview of BIC System components

4. Terminology

See User Manual chapter 4.2

5. Main Functions

The main functions/performance of the system is the recording of neural signals, modulation of neural activity by delivering electrical pulses to the neural tissue (hereinafter referred to as *stimulation*) and measuring of electrode impedance. The latter permits to not only to evaluate the integrity of the technical system but also the biological response to the Implanted Grid Electrodes.

Starting the launcher by clicking the launcher icon (Figure 2)

Figure 2: Application Software launcher icon on MS Windows desktop.

The functional elements of the graphical user interface (GUI) of the Application Software is shown in Figure 3: Signal visualization and control panels.

Recorded signal visualisation

Control panels

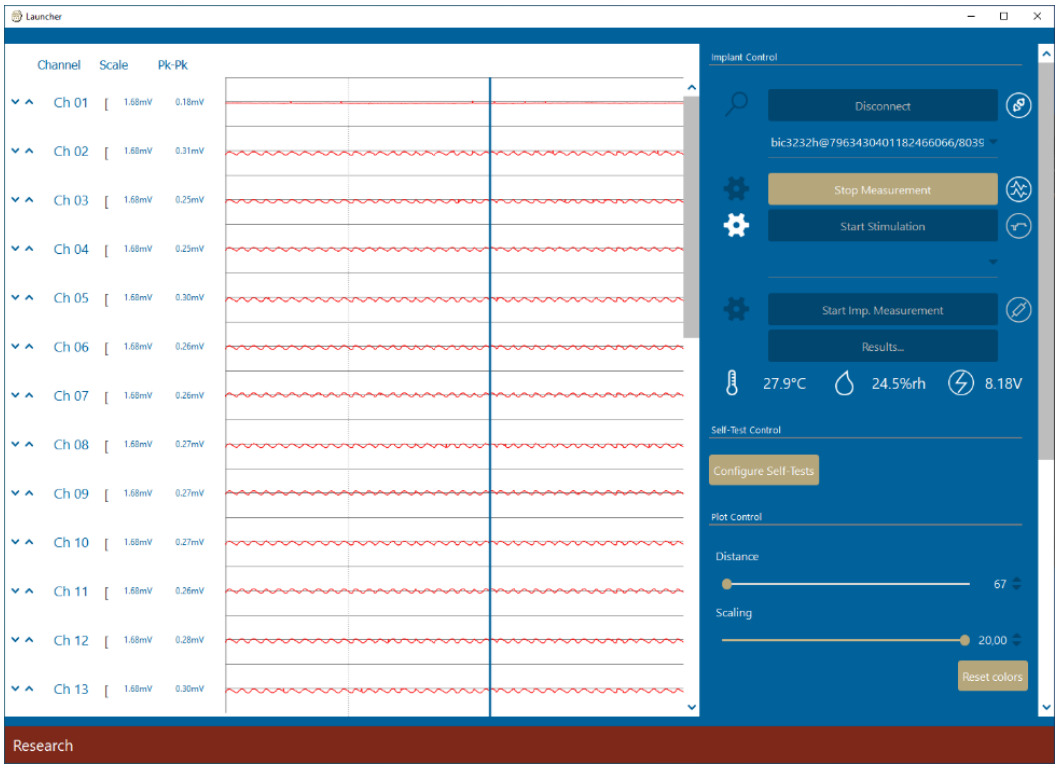


Figure 3: Graphical User Interface of Application Software.

5.1. Connect / Disconnect

Connection to an implant refers to having the implanted and the body-external components communicate to each other. First, implants in reach (inductively powered and addressable by radio frequency communication) need to be discovered by clicking on the magnification lens icon in the implant control panel (Figure 4).

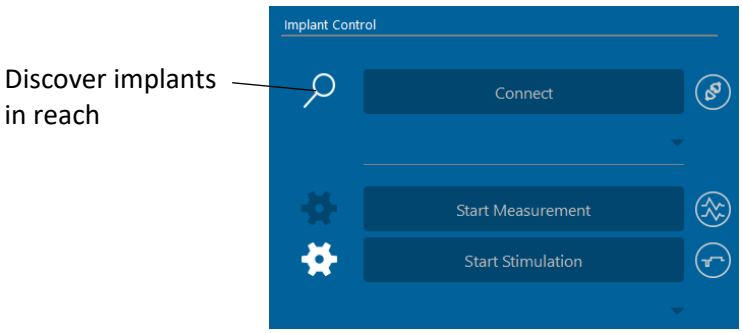


Figure 4: Initiate the discovery of implants by click on the magnification lens symbol.

Once one or more implants are discovered, the implant to be connected to needs to be selected from the list of implants in reach (Figure 5). In second step the *Connect* button needs to be clicked on.

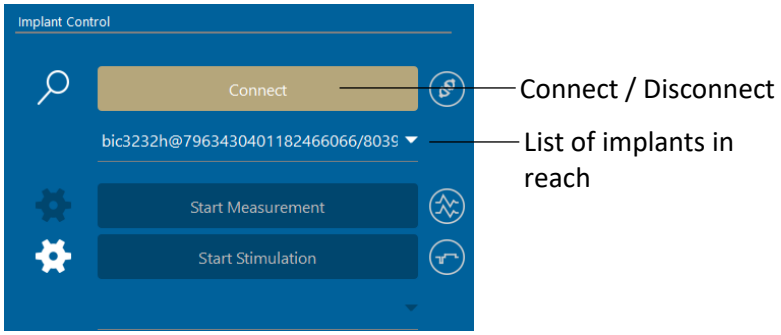


Figure 5: Connect to an implant by selecting the identification number and clicking on the Connect button.
The same button is used for disconnection.

Once connected the label of the connect button changes to *Disconnect*.
Disconnection from the implant by clicking on the *Disconnect* button finishes the tasks carried out by the implant and shuts down the implant power supply. If the Application Software is closed without disconnecting, the implant will be further powered. It will although continuing the current task.

5.2. Record Neural Signals

5.2.1. Selection of Recording Refence

Recording of neural signals requires the amplification of the electrical potentials seen by each recording electrode referred to the electrical potential sensed by one or more reference electrode contacts.
Since each electrode contact can work as recording reference, this selection must be done before recording can be started.

In some applications, a hard-wired reference electrode contact is used. In this case, the selection of a recording reference adds an additional reference contact to the hardwired reference contact.

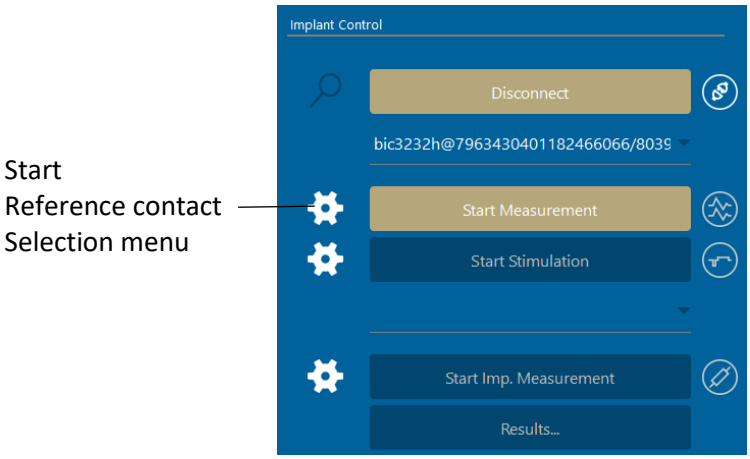


Figure 6: Clicking on the gear symbol opens a new window that permits the selection of the reference electrode contact(s).

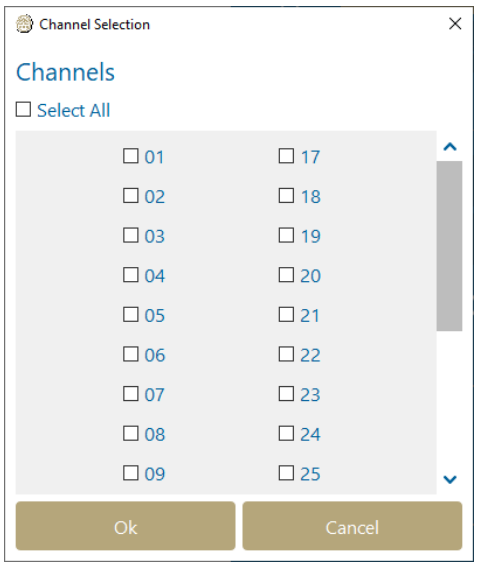


Figure 7: Channel selection menu

After selection of the reference channel(s), close the menu by clicking on *Ok*. The measurement is started by clicking on *Start Measurement* in the Implant Control Panel.

5.2.2. Start / Stop Measurement

Once the recording reference contacts are defined (could be more than one contact), the recording can be started

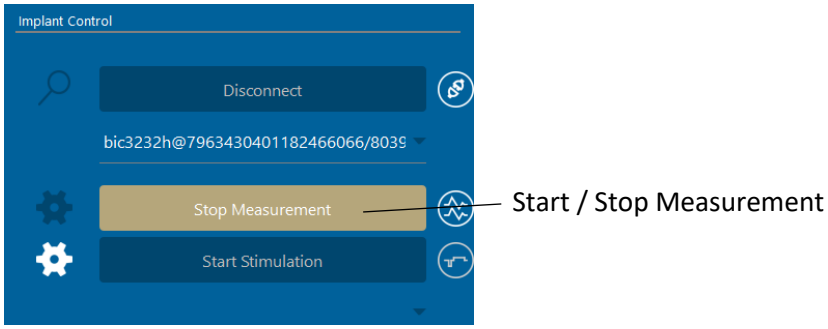


Figure 8: Recording is started by clicking on the button Start Measurement. The same button is used to stop the measurement.

Once the recording started, the digitized data is displayed on the screen.

5.2.3. Plot Control

The display of the data stream can be adjusted by the user:

- **Distance**
  The distance between two channels can be adjusted
- **Scaling**
  The amplitude scale of all channels can be adjusted

Note: These settings have no influence on the data stored to file.

5.2.4. Application Log

All logs (status reports, error messages etc.) are displayed in this section. These logs are stored to file.

5.2.5. Frequency Filters

The recorded data can be frequency filtered before display.

- **Notch Filter**
  Notch filters remove artifacts associated with one frequency. Often used to reject mains frequency (50 Hz in Europe, 60 Hz in the USA).
- **Low Pass Filters**
  The filters permit to reject signal content at selected frequencies and above.

Note: These settings have no influence on the data stored to file.

5.2.6. Data Storage

The data (neural data and system logs) is stored to files in a binary file format.
A converter tool (bip2csv.py) translates these binary files into CSV files, that can be read, e.g. by Microsoft Excel or Mathworks' Matlab.
To use the converter tool, the path to the src directory must be added to the PYTHONPATH system variable. Start the tool by typing on prompt:

```
python bip2csv.py -c example.json -i path_to_data_file.log
```

Note: The converter tool has been tested with Python 3.7.4 and it is recommended to use this version.

The result is a table which rows correspond to the packets transferred from the implant to the Communication Unit/Personal Computer; the columns of the table are described below.

Column 1:	timestamp (ms) Ignore this for data analysis, since it is the time of packet arrival on the PC side, which is not a real-time system. Instead, use the sampling rate of 1000 Hz.
Column 2 to 33:	voltage (µV) recorded from channel 1 to 32
Column 34:	source of data stream
Column 35:	measurement counter, increments with each measurement packet
Column 36:	trigger signal (binary)

Note: Every time a packet is lost, a row with 'nan' values is added for each column. It is up to the user to replace these 'nan' values, e.g. by interpolated values.

5.3. Apply Electrical Stimulation

5.3.1. Define Stimulus

Stimulation commands can either be selected from a pre-defined list of commands or newly defined (Figure 10).

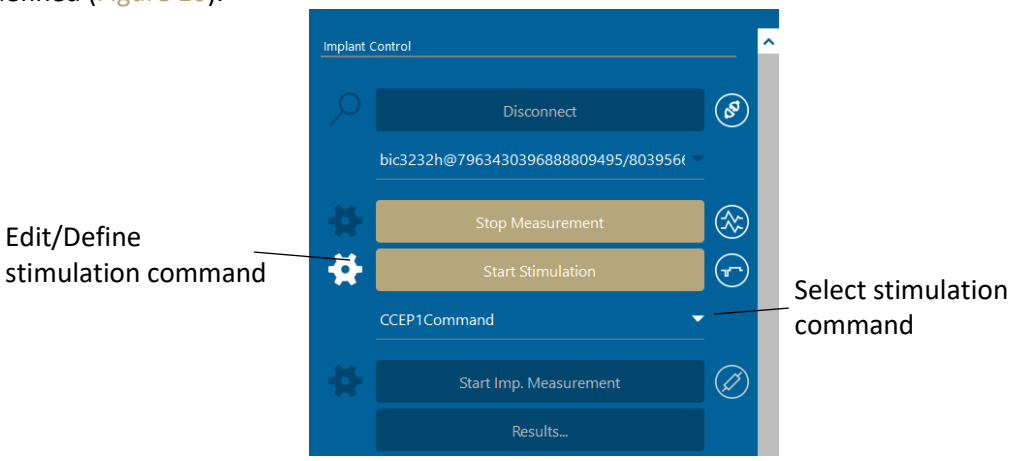


Figure 9: Clicking on the gear symbol opens a new window that permits the definition of the stimulation pattern.

New definition or editing of stimulation commands is done using the Stimulation Command Editor (Figure 10). When opening this dialog for the first time, a list of pre-defined commands is created.

Figure 10: Stimulation Command Editor. Stimulation commands can be edited, or new command can be added.

The Stimulation Command Editor permits the selection of pre-defined stimulation commands as well as the definition of a new stimulation command (select the *Add* button).

The timing and amplitude parameters define the stimulation pulse according to Figure 11. The selection of Source/Destination channels defines the actual stimulation electrode function: The current leaves the implant through the source contact(s), pass the tissue and re-enter the implant through the destination contacts, and/or the Ground contact.

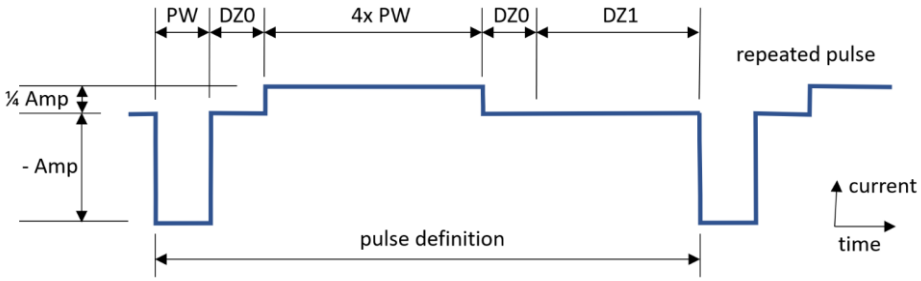


Figure 11: Definition of a pulse by timing (PW, DZ0, DZ1) and amplitude (Amp) parameters.

Note: The implant has four stimulation sources that use identical timing but could. Each stimulation source might use different amplitudes (Amplitude 1 – Amplitude 4). Amplitude 1 refers to the stimulation source that can freely be directed to any of the electrode contacts (channels). The sources 2-4 are hardwired to dedicated electrode contacts (channels), depending on the individual implant configuration produced by CorTec.

By selecting the okay button on the lower left corner, the drop-down menu (Figure 8Figure 9) is filled with the commands that are available in the Stimulation Command Editor. They are now ready to be started using the implant control window.

5.3.2. Start / Stop Electrical Stimulation

The stimulation command shown below the *Start Stimulation Button* in the implant control panel can be started by selecting the *Start Stimulation* Button (Figure 12). For the duration of stimulation, the button changes its label to *Stop Stimulation*. In case the stimulation needs to be aborted, this button needs to be clicked on. After the stimulation command is finished (or was aborted) the label of the button switches back to *Start Stimulation*.

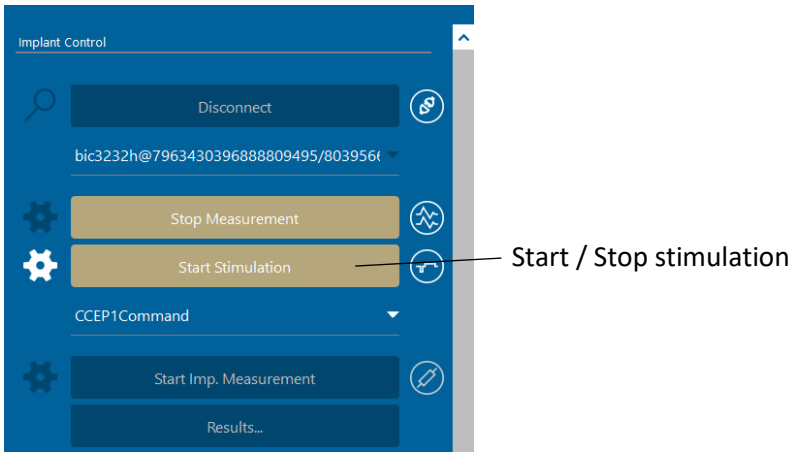


Figure 12: Stimulation is started by clicking on the button Start Stimulation. The same button is used to stop the stimulation, in case it is to be interrupted before the intendent end of the stimulation pattern.

5.4. Measure Impedance

The impedance of each electrode (exception: the dedicated Ground electrode and a hard-wired reference electrode, if existent) can be measured using the application software. First, the electrode contact(s) to be measured has to be defined in the channel selection menu. Then the impedance measurement is started by clicking on the button *Start Imp. Measurement*. The last results of the measurements are displayed by clicking on the button *Results*.

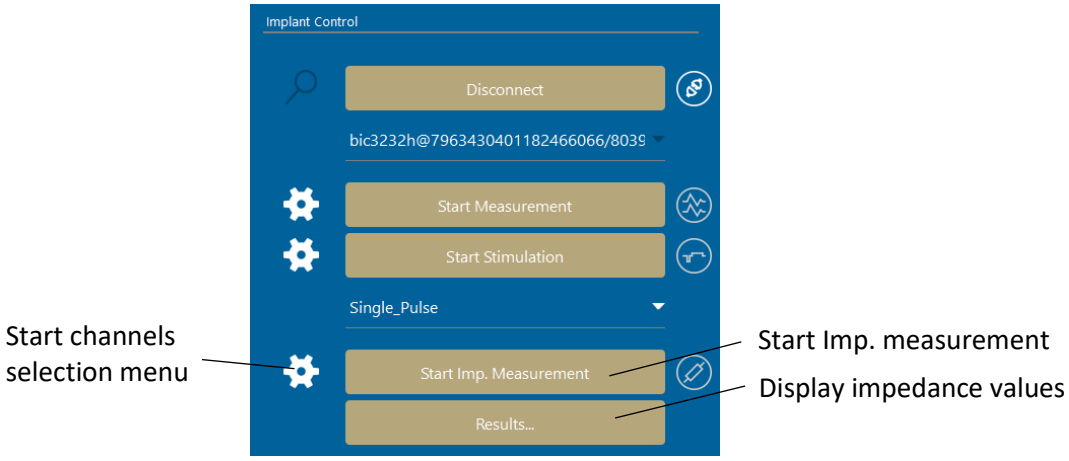


Figure 13: Functions of control panel related to impedance measurement of electrode contacts.

Note: The impedance values measured correlate to the ohmic access resistance calculated by measuring the voltage step height in response to a current pulse divided by the pulse amplitude. This value is strongly influenced by change of the electrode environment, e.g. by fibrotic tissue growth as well as by the cable resistance, allowing to discover onset of electrode breakage.

CorTec GmbH
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