Aid to Programming:

Algorithm and Check List for Electrode Configurations

Patient name: _____ Medical Record No. _____

Date of Birth: Month _____ Day_____ Year _____

Diagnosis: _____ DBS target: _____

DBS side: _____

The designations for the contacts used here assume that the DBS lead contains four potential cathodes arranged linearly along the axis of the lead. The contacts are designated as most ventral, ventral, dorsal, most dorsal (**Figure 1**). Electrode configurations are described as monopolar (DBS lead contacts as cathodes and the IPG as anode), wide bipolar (both anode and cathodes on the DBS lead and there are two contacts between the anode and cathode), close bipolar (both anode and cathodes on the DBS lead and there are one contacts between the anode and cathode), and narrow bipolar (both anode and cathodes on the DBS lead and there are no contacts between the anode and cathode).

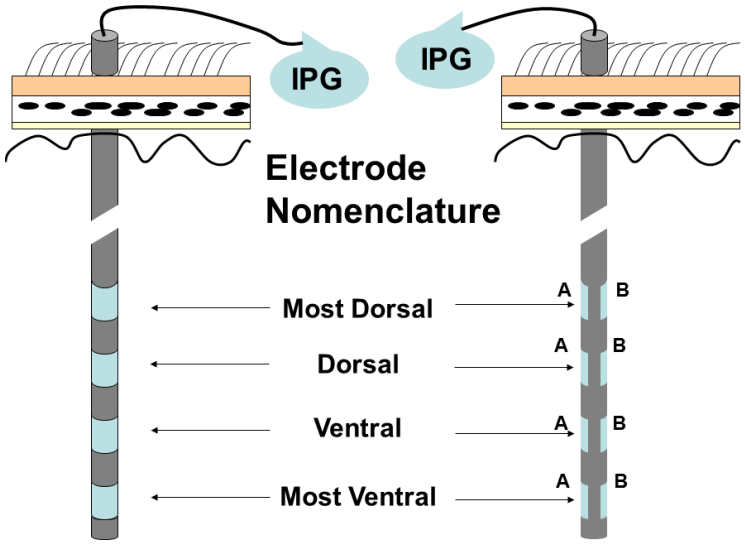

Figure 1. As there is no cross-manufacturer standardization of nomenclatures for DBS electrical contacts on DBS leads, the programmer needs to exercise care in documentation of the various electrode configurations used. The convention suggested here presumes a DBS lead architecture in which the contacts are organized along the long axis of the DBS lead. This translates into a relative location within the brain as a function of the manner of DBS lead implantation. In the event segmented leads are utilized, the above suggestion can be generalized to identify each segment by some label but still organized by the relative anatomical position in the brain. The programmer should take the responsibility of exactly specifying the DBS lead manufacturer and model type of the DBS lead used in every piece of documentation related to the patient's care, particularly for DBS leads whose number of contacts or architectures prove cumbersome of intuitive naming.

Conventional	Alternative
Starting with the conventional DBS frequency of 130 pps, pulse width of 60 microseconds and stimulation intensity of 0 mA (0 volts) go to A1.	Parkinson's disease (and perhaps other disorders) starting with the optimal DBS frequency defined by the monopolar survey, set pulse width to 150 microsecond, set stimulation intensity to 0, and go to B1.
A1. Increase stimulation intensities by 0.5 mA (0.5 v for constant current-voltage IPGs), assess and go to A2.	B1. Increase stimulation intensities by 0.5 mA (0.5 v for constant current-voltage IPGs), assess and go to B2.
A2. If assessment demonstrates - a) Insufficient benefit in the absence of adverse effects go to A1. a) Sufficient benefit achieved - proceed to exit procedures (*Chapter 9 - Approaches to Programming, Montgomery Jr. EB, Deep Brain Stimulation Programming: Mechanisms, Principles and Practice, 2nd edition, Oxford University Press*). b) Encounter a limiting adverse effect – reset stimulus intensity to 0, return pulse width and DBS frequency to starting value, and	B2. If assessment demonstrates - a) Insufficient benefit in the absence of adverse effects go to B1. a) Sufficient benefit achieved - proceed to exit procedures (*Chapter 9 - Approaches to Programming, Montgomery Jr. EB, Deep Brain Stimulation Programming: Mechanisms, Principles and Practice, 2nd edition, Oxford University Press*). b) Encounter a limiting adverse effect – reset stimulus intensity to 0 and return to algorithm below for possible change in electrode configuration

return to algorithm below for possible change in electrode configuration c) Reach 4 mA (5 v for constant current-voltage IPGs) without sufficient clinical benefit and absent adverse effects and i) DBS frequency is not at maximum, return stimulation intensity to 0, increase DBS frequency and return to A1. ii) DBS frequency at maximum, proceed to A3.	c) Reach 4 mA (5 v for constant current-voltage IPGs) without sufficient clinical benefit and absent adverse effects, set stimulation intensity to 0 and return to algorithm below for possible change in electrode configuration. Alternatively, particularly if reasonable electrode configurations have been exhausted, consider implementing the conventional approach described in this table.
A3. a) If DBS pulse width not at maximum reset stimulation intensity to 0, return DBS frequency to starting value, increase pulse width and go to A1. b) If DBS pulse width at maximum, reset stimulation intensity to 0, return pulse width and frequency to starting value, and return to algorithm below for possible change in electrode configuration.	

Table – Stimulation parameter adjustment. Two approaches to adjustments of the stimulation parameters. Column 1 is an algorithm based on conventional approaches as described in the text. Column 2 is an alternative approach based on studies of DBS frequency

and chronaxie as discussed in the text. Note, the specific stimulation parameters are suggestions and may vary with different implanted pulse generators and different manufacturers. The programmer is advised to consult with the manufacturer's recommendations.

Step 1. Start

Single cathode (-) monopolar stimulation

Most Ventral contact cathode (-); case anode (+)

Change stimulation parameters as described in *Table – Stimulation parameter adjustment*

Adverse effects: go to step 1.1 ____ yes ____ no

Lack of efficacy: go to step 1.1 ____ yes ____ no

__ Done if checked

Comments: _____

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Step 1.1 Single cathode (-) monopolar stimulation

Ventral contact cathode (-); case anode (+)

Change stimulation parameters as described in *Table – Stimulation parameter adjustment*

Adverse effects: go to step 1.2 ____ yes ____ no

Lack of efficacy: go to step 1.2 ____ yes ____ no

__ Done if checked

Comments: _____

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Step 1.2 Single cathode (-) monopolar stimulation

Dorsal contact cathode (-); case anode (+)

Change stimulation parameters as described in *Table – Stimulation parameter adjustment*

Adverse effects: go to step 1.3 ____ yes ____ no

Lack of efficacy: go to step 1.3 ____ yes ____ no

__ Done if checked

Comments: _____

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Step 1.3 Single cathode (-) monopolar stimulation

Most Dorsal contact cathode (-); case anode (+)

Change stimulation parameters as described in *Table – Stimulation parameter adjustment*

Adverse effects: go to step 2.0 ____ yes ____ no

Lack of efficacy: go to step 2.0 ____ yes ____ no

__ Done if checked

Comments: _____

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Step 2.0 Wide bipolar polar stimulation

Most Ventral contact cathode (-);

Most Dorsal contact anode (+)

Change stimulation parameters as described in *Table – Stimulation parameter adjustment*

Adverse effects: go to step 2.1 ____ yes ____ no

Lack of efficacy: go to step 2.1 ____ yes ____ no

__ Done if checked

Comments: _____

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Step 2.1 Wide bipolar polar stimulation

Most Ventral contact anode (+); Most Dorsal contact cathode (-)

Change stimulation parameters as described in *Table – Stimulation parameter adjustment*

Adverse effects: go to step 3.0 ____ yes ____ no

Lack of efficacy: go to step 3.0 ____ yes ____ no

__ Done if checked

Comments: _____

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Step 3.0 Multiple cathodes (-) monopolar stimulation

Most Ventral and Ventral contacts cathode (-); case anode (+)

Check therapeutic impedances

Change stimulation parameters as described in *Table – Stimulation parameter adjustment*

Adverse effects: go to step 3.1 ____ yes ____ no

Lack of efficacy: go to step 3.1 ____ yes ____ no

__ Done if checked

Comments: _____

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Step 3.1 Multiple cathodes (-) monopolar stimulation

Ventral and Dorsal contacts cathode (-); case anode (+)

Check therapeutic impedances

Change stimulation parameters as described in *Table – Stimulation parameter adjustment*

Adverse effects: go to step 3.2 ____ yes ____ no

Lack of efficacy: go to step 3.2 ____ yes ____ no

__ Done if checked

Comments: _____

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Step 3.2 Multiple cathodes (-) monopolar stimulation

Dorsal and Most Dorsal contacts cathode (-); case anode (+)

Check therapeutic impedances

Change stimulation parameters as described in *Table – Stimulation parameter adjustment*

Adverse effects: go to step 4.0 ____ yes ____ no

Lack of efficacy: go to step 4.0 ____ yes ____ no

__ Done if checked

Comments: _____

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Step 4.0 Wide multiple cathode (-) bipolar stimulation

Most Ventral and Ventral contacts cathode (-)

Most Dorsal contact anode (+)

Change stimulation parameters as described in *Table – Stimulation parameter adjustment*

Adverse effects: go to step 4.1 ____ yes ____ no

Lack of efficacy: go to step 4.1 ____ yes ____ no

__ Done if checked

Comments: _____

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Step 4.1 Wide multiple cathode (-) bipolar stimulation

Most Dorsal and Dorsal contact cathodes (-)

Most Ventral contact anode (+)

Change stimulation parameters as described in *Table – Stimulation parameter adjustment*

Adverse effects: go to step 5.0 ____ yes ____ no

Lack of efficacy: Check system for hardware failure, confirm correct DBS lead location. Note that interleaved configurations and parameters have not been recommended at this point in the algorithm for two reasons. First, there is insufficient experience with this method. Second and based on principle, the most likely use of the interleaved stimulation will be to deal with side effects which are not the issue at this point in the algorithm. Further, monopolar and wide bipolar configurations are most likely to have the highest efficacy and would already have been tested by this point in the algorithm.

__ Done if checked

Comments: _____

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Step 5.0 Close single cathode (-) bipolar stimulation

Most Ventral contact cathode (-); Dorsal contact anode (+)

Change stimulation parameters as described in *Table – Stimulation parameter adjustment*

Adverse effects: go to step 5.1 ____ yes ____ no

Lack of efficacy: go to step 5.1 ____ yes ____ no

__ Done if checked

Comments: _____

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Step 5.1 Close single cathode (-) bipolar stimulation

Ventral contact cathode (-); Most Dorsal contact anode (+)

Change stimulation parameters as described in *Table – Stimulation parameter adjustment*

Adverse effects: go to step 5.2 ____ yes ____ no

Lack of efficacy: go to step 5.2 ____ yes ____ no

__ Done if checked

Comments: _____

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Step 5.2 Close single cathode (-) bipolar stimulation

Most Dorsal contact cathode (-); Ventral contact anode (+)

Change stimulation parameters as described in *Table – Stimulation parameter adjustment*

Adverse effects: go to step 5.3 ____ yes ____ no

Lack of efficacy: go to step 5.3 ____ yes ____ no

__ Done if checked

Comments: _____

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Step 5.3 Close single cathode (-) bipolar stimulation

Dorsal contact cathode (-); Most Ventral contact anode (+)

Change stimulation parameters as described in *Table – Stimulation parameter adjustment*

Adverse effects: go to step 7.0 ____ yes ____ no

Lack of efficacy: go to step 6.0 ____ yes ____ no

__ Done if checked

Comments: _____

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Step 6.0 Close multiple cathodes (-) bipolar stimulation

Most Ventral and Ventral contacts cathode (-); Dorsal contact anode (+)

Change stimulation parameters as described in *Table – Stimulation parameter adjustment*

Adverse effects: go to step 6.1 ____ yes ____ no

Lack of efficacy: go to step 6.1 ____ yes ____ no

__ Done if checked

Comments: _____

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Step 6.1 Close multiple cathodes (-) bipolar stimulation

Ventral and Dorsal contacts cathode (-); Most Dorsal contact anode (+)

Change stimulation parameters as described in *Table – Stimulation parameter adjustment*

Adverse effects: go to step 6.2 ____ yes ____ no

Lack of efficacy: go to step 6.2 ____ yes ____ no

__ Done if checked

Comments: _____

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Step 6.2 Close multiple cathodes (-) bipolar stimulation

Most Dorsal and Dorsal contact cathodes (-); Ventral contact anode (+)

Change stimulation parameters as described in *Table – Stimulation parameter adjustment*

Adverse effects: go to step 6.3 ____ yes ____ no

Lack of efficacy: go to step 6.3 ____ yes ____ no

__ Done if checked

Comments: _____

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Step 6.3 Close multiple cathodes (-) bipolar stimulation

Dorsal and Ventral contacts cathodes (-); Most Ventral contact anode (+)

Change stimulation parameters as described in *Table – Stimulation parameter adjustment*

Adverse effects: go to step 7.0 ____ yes ____ no

Lack of efficacy: Check system for hardware failure, confirm correct DBS lead location. Note that interleaved configurations and parameters have not been recommended at this point in the algorithm for two reasons. First there is insufficient experience with this method. Second and based on principle, the most likely use of the interleaved stimulation will be to deal with side effects which are not the issue at this point in the algorithm. Further, monopolar, wide bipolar, and close bipolar configurations are

most likely to have the highest efficacy and would already have been tested by this point in the algorithm.

__ Done if checked

Comments: _____

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Step 7.0 Narrow single cathode (-) bipolar stimulation

Most Ventral contact cathode (-); Ventral contact anode (+)

Change stimulation parameters as described in *Table – Stimulation parameter adjustment*

Adverse effects: go to step 7.1 ____ yes ____ no

Lack of efficacy: go to step 7.1 ____ yes ____ no

__ Done if checked

Comments: _____

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Step 7.1 Narrow single cathode (-) bipolar stimulation

Ventral contact cathode (-); Dorsal contact anode (+)

Change stimulation parameters as described in *Table – Stimulation parameter adjustment*

Adverse effects: go to step 7.2 ____ yes ____ no

Lack of efficacy: go to step 7.2 ____ yes ____ no

__ Done if checked

Comments: _____

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Step 7.2 Narrow single cathode (-) bipolar stimulation

Dorsal contact cathode (-); Most Dorsal contact anode (+)

Change stimulation parameters as described in *Table – Stimulation parameter adjustment*

Adverse effects: go to step 7.3 ____ yes ____ no

Lack of efficacy: go to step 7.3 ____ yes ____ no

__ Done if checked

Comments: _____

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Step 7.3 Narrow single cathode (-) bipolar stimulation

Ventral contact cathode (-); Most Ventral contact anode (+)

Change stimulation parameters as described in *Table – Stimulation parameter adjustment*

Adverse effects: go to step 7.4 ____ yes ____ no

Lack of efficacy: go to step 7.4 ____ yes ____ no

__ Done if checked

Comments: _____

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Step 7.4 Narrow single cathode (-) bipolar stimulation

Dorsal contact cathode (-); Ventral contact anode (+)

Change stimulation parameters as described in *Table – Stimulation parameter adjustment*

Adverse effects: go to step 7.5 ____ yes ____ no

Lack of efficacy: go to step 7.5 ____ yes ____ no

__ Done if checked

Comments: _____

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Step 7.5 Narrow single cathode (-) bipolar stimulation

Most Dorsal contact cathode (-); Dorsal contact anode (+)

Change stimulation parameters as described in *Table – Stimulation parameter adjustment*

Adverse effects: go to step 8.0 ____ yes ____ no

Lack of efficacy: Check system for hardware failure, confirm correct DBS lead location

__ Done if checked

Comments: _____

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Step 8.0 Narrow multiple anodes (+) tripolar stimulation

Dorsal and Most Ventral contacts anodes (+); Ventral contact cathode (-)

Change stimulation parameters as described in *Table – Stimulation parameter adjustment*

Adverse effects: go to step 8.1 ____ yes ____ no

Lack of efficacy: go to step 8.1 ____ yes ____ no

__ Done if checked

Comments: _____

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Step 8.1 Narrow multiple anodes (+) tripolar stimulation

Most Dorsal and Ventral contacts anodes (+); Dorsal contact cathode (-)

Change stimulation parameters as described in *Table – Stimulation parameter adjustment*

Adverse effects: ____ yes ____ no

At this point interleaved configurations and parameters should be tried.

The stimulation current/voltage can be apportioned based on the side

effect profile and efficacy. For example, if stimulation of the Most Ventral contact provided greater efficacy but with significant side effects while the ventral contact produced less efficacy but no side effects, the first step would be to apply the maximum stimulation current/voltage tolerated on the Most Ventral contact and then the maximum stimulation current/voltage tolerated on the Ventral contact and determine whether this resulted in sufficient efficacy without significant side effects. If this fails check system for hardware failure, confirm correct DBS lead location.

Lack of efficacy: check system for hardware failure, confirm correct DBS lead location ____ yes ____ no

__ Done if checked

Comments: _____

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