

g·ESTIMPRO

CORTICAL STIMULATOR



INSTRUCTIONS FOR USE





Instructions for Use
g.Estim PRO
Version 1.24.01 | Revision 1.21

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UDI Label

CONTENTS

1	CONVENTIONS	1
2	IMPORTANT NOTES.....	2
2.1	THE INTENDED USE OF THE EQUIPMENT	2
2.2	THE INTENDED ENVIRONMENT OF USE.....	2
2.3	INDICATIONS FOR USE.....	2
2.4	LIMITATIONS.....	2
2.5	INTENDED USER.....	2
2.6	CONTRAINDICATIONS	2
2.7	RELEASE NOTES.....	3
2.8	WARNINGS, CAUTIONS, AND NOTES	4
2.9	WARNING AND SAFETY NOTICE	10
2.10	INSPECTION	10
2.11	INTERFERENCE.....	12
3	INTRODUCTION TO G.ESTIM PRO	14
4	TERMINOLOGY.....	15
4.1	COMMON TERMS	15
4.2	STIMULATION PARAMETERS.....	15
5	G.ESTIM PRO SYSTEM	17
6	G.ESTIM PRO.....	19
6.1	LABELS, SOCKETS AND LEDS ON THE FRONT SIDE.....	19
6.2	SOCKETS, SWITCH AND BATTERY HOLDERS ON THE REAR SIDE	20
6.3	LABELS ON THE TOP SIDE	21
6.4	DIGITAL INPUT/OUTPUT FUNCTIONALITY	22
6.5	USB CABLE	23
6.6	TRIGGER INPUT CABLE	24
6.7	TRIGGER OUTPUT CABLE	25
6.8	PORTABLE CASE	26
6.9	FOOT SWITCH.....	27
6.10	HAND SWITCH.....	28
6.11	COMPUTER	29
6.12	TRADEMARK NOTICE.....	29
6.13	BATTERY	30
6.14	STIMULATION ELECTRODES	30
6.14.1	GRID/STRIP ELECTRODES	31

6.14.2	DEPTH ELECTRODES.....	31
6.14.3	HAND-HELD ELECTRODES.....	31
6.14.4	ELECTRODE CONNECTOR CABLE.....	33
6.15	G.HIAMP.....	33
6.16	G.USBAMP	34
7	SAFE OPERATION OF G.ESTIM PRO.....	36
7.1	SETUP.....	36
7.2	START.....	38
7.3	RECORDING INTRACRANIAL EEG WHILE STIMULATING	40
7.4	SWITCHING OFF AND STORAGE OF G.ESTIM PRO	41
7.5	BATTERY REPLACEMENT.....	42
8	GENERAL NOTES.....	43
8.1	CLASSIFICATION	43
8.2	TRANSPORTATION AND STORAGE CONDITIONS	43
8.3	OPERATION CONDITIONS.....	43
8.4	WASTE DISPOSAL DETAILS	43
8.5	CLEANING	44
8.6	WARRANTY	44
9	DECLARATION OF CONFORMITY.....	45
10	TECHNICAL SPECIFICATIONS G.ESTIM PRO	46
11	ELECTROMAGNETIC COMPATIBILITY	48
11.1	GUIDANCE AND MANUFACTURER'S DECLARATION	48
11.1.1	ELECTROMAGNETIC EMISSION.....	49
11.1.2	ELECTROMAGNETIC IMMUNITY	49
12	APPENDICES.....	54

1 CONVENTIONS

The following conventions are used to direct the attention of the reader to important safety information.



WARNING:

A warning informs about possible injury or death that could result from the use or misuse of the device.



CAUTION:

A caution informs about possible injury or malfunctions of the device or other equipment that could result from the use or misuse of the device.



NOTE:

Notes provide information such as recommendations, best practices or other information.

2 IMPORTANT NOTES

2.1 THE INTENDED USE OF THE EQUIPMENT

The g·Estim PRO is intended for functional brain mapping via electrical stimulation prior to cortical resections in the vicinity of essential cortex. The device must be used by medically trained and qualified personnel within a medical environment.

2.2 THE INTENDED ENVIRONMENT OF USE

The device must not be used in dangerous conditions such as wet rooms or explosive environments. The device must not be used in combination with any high-frequency medical device. The usage of a high frequency device together with g·Estim PRO can result in burning under the electrodes and could damage the stimulator. Please consider the environmental conditions for safe operation, storage and transportation described in Section 8.

2.3 INDICATIONS FOR USE

The indication for usage of the g·Estim PRO for functional brain mapping is given when functionally relevant areas on the cortex (also known as eloquent/essential cortex) have to be identified. This is the case for example in patients with brain tumors or epilepsy where resective surgeries are indicated that aim for removing pathologic, but preserving functionally relevant tissue.

2.4 LIMITATIONS

The g·Estim PRO is a constant current stimulator that requires a stimulation probe to achieve the clinical performance of functional brain mapping.

2.5 INTENDED USER

The device must be used either by a medical expert, such as a medical doctor with expertise in the field of neurology or neurosurgery, or by a medical technical assistant under the supervision of a medical doctor. A user is only eligible to operate the device after completed device training.

2.6 CONTRAINDICATIONS

The following conditions are usually considered contraindications.

Absolute:

- Application of a defibrillator.
- Application of a high-frequency device (e.g. electrosurgical unit (ESU)).
- Presence of metal (e.g. surgical surface staples or external pins) in the target stimulation area.
- Patient is non-compliant to planned procedures due to age, cognitive function, or cognitive development stage.

Relative:

- Presence of active or passive implanted medical devices.
- Presence of implanted metallic fragments, electrodes, lead wires, etc.
- Suspected or diagnosed cortical lesions.

- Suspected or diagnosed epilepsy and/or seizures.
- Suspected or diagnosed increased brain pressure.
- Suspected or diagnosed neurological or psychological disorders.
- Suspected or diagnosed cardiac disease.
- Presence of vascular clips or shunts, or endovascular coils.
- Anesthesia or other medication.
- Target stimulation areas that lack normal sensation.
- Inability of the patient to report discomfort or pain.
- Pregnancy.
- Lower-than normal body temperature.

2.7 RELEASE NOTES

1.18.02

- Improved robustness of self-test procedure
- Fixed bug of pulse counter display at low frequencies using hand switch
- Minor improvements of IFU

1.18.06

- Improved robustness of self-test procedure
- Updated OS version

1.18.07

- New logo design
- Support for additional batteries
- Selectable stimulation polarity in basic mode
- Support of hand-held probes with high impedance
- Review of help areas

1.20.00

- Software available for download in g.tec Suite

1.20.01

- Update of electromagnetic compatibility (EMC)

1.24.00

- Updated OS version
- Black edition

1.24.01

- Control Software update with improved sequence onset jitter
- Storage case label update

2.8 WARNINGS, CAUTIONS, AND NOTES



WARNING:

- The device must not be used during defibrillation.
- The device must not be used together with high-frequency equipment. The usage of high-frequency devices together with the g.Estim PRO can result in tissue burns under the electrodes and could damage the stimulator. When using an electrosurgical unit (ESU), remove or disconnect all electrodes that are in the high frequency current path between the ESU tip and return plate.
- The device must not be used when the electrodes are in contact with or near protruding metal such as surgical surface staples or external pins, because they are excellent conductors of electricity.
- The device must not be used when a patient is non-compliant to planned procedures due to age, cognitive function, or cognitive development stage. Such procedures might depend on the active cooperation of the patient and/or a sufficiently developed brain, and/or other aspects. Confirm compliance by a task without stimulation.

Generally, patients that are eligible for brain surgery in general and the individual type of surgery (e.g. epilepsy, tumor, or similar) in particular are also eligible for the usage of this device. In the individual case the responsible surgeon has to decide upon the procedures and the usage of the device.

- After careful evaluation of potential risks and obtaining patient consent, the physician in charge must approve the stimulation of patients with the following conditions, as they might constitute relative contraindications and special precautions might be necessary:
 - Patients with active or passive implanted medical devices.
 - Patients with implanted metallic fragments, electrodes, lead wires, etc.
 - Patients with suspected or diagnosed cortical lesions.
 - Patients with suspected or diagnosed epilepsy and/or seizures.
 - Patients with suspected or diagnosed increased brain pressure.
 - Patients with suspected or diagnosed neurological or psychological disorders.
 - Patients with suspected or diagnosed cardiac disease.
 - Patients with a history of cerebral aneurysm treatment using surgical devices like vascular clips or shunts, or endovascular coils.
 - Patients under anesthesia or other medication.
 - Patients or stimulation areas which lack normal sensation.
 - Patients who may not be able to report discomfort or pain.
 - Pregnant patients.
 - Patients with lower-than normal body temperature.

MacDonald D.B.: Safety of Intraoperative Transcranial Electrical Stimulation Motor Evoked Potential Monitoring. J. Clin. Neurophysiol. 19(5): 416-429, 2002

MacDonald D.B.: Intraoperative Motor Evoked Potential Monitoring: Overview and Update. J. Clin. Monitoring and Computing. 20(5): 347-377, 2006

- The device must only be operated by medical professionals, who underwent training for g.Estim PRO by g.tec medical engineering GmbH.
- The device must not be used directly on the heart.
- The device must not be used for stimulation near or through the chest (transthoracically), as applying electrical stimulus current to any region of the

thorax can lead to ventricular fibrillation or other cardiac arrhythmias. Never use electrodes contralaterally, i.e. do not use two electrodes on opposite segments of the body.

- The device must not be used for stimulation directly on the eyes or inside body cavities.
- The device must not be used for stimulation when the mouth of the patient is covered.
- The device must not be used for stimulation of the front side of the throat (carotid sinus nerves), particularly in patients with a known sensitivity to the carotid sinus reflex.
- The device must not be used for stimulation of the neck or mouth. Severe spasm of the laryngeal and pharyngeal muscles may occur and the contractions may be strong enough to close the airway or cause difficulty in breathing.
- The device must not be used for stimulation with electrodes mounted on the chest and the upper back or crossing the heart.
- The device must not be used in environments that do not meet the environmental conditions defined in the Instructions For Use.
- The device must not be used in the presence of any flammable anesthetic gas or high concentration oxygen atmosphere. Failure to follow this warning may cause explosion or fire.
- The device must not be used in the presence of magnetic fields (e.g. MRI scanners). Before an MRI test, remove all electrodes from the patient and remove the g.Estim PRO and all accessories, removable components and electrodes from the MRI chamber.
- The device must not be used when the device or its accessories or components show damage of the housing, connectors, sockets, cables or other parts. Damaged parts must be replaced immediately. For repair or replacement, contact g.tec medical engineering GmbH.
- To avoid erroneous diagnoses, the interpretation of stimulation results must be done only by medical doctors.
- Monophasic stimulation on the same stimulation site can lead to serious tissue damage under the electrodes if applied over a long period of time due to the charge transfer in the body electrolytes (electrolysis). It is therefore not allowed.
- Potential hazards to the patient resulting from stimulation:
 - Bite injuries (use a mouth gum shield if necessary)
 - Seizure
 - Tissue burn
 - Intraoperative awareness
 - Muscle contractions
 - Periosteal/dural/other pain
 - Anxiety
 - Tiredness
- Severe tissue damage can occur for absolute charge transfer $> 15\mu\text{C}$. Stimulation of a single electrode pair location with $> 15\mu\text{C}$ is therefore forbidden.
D. B. McCreery, W. F. Agnew, T. G. Yuen, and L. Bullara, "Charge density and charge per phase as cofactors in neural injury induced by electrical stimulation," IEEE Trans Biomed Eng, vol. 37, no. 10, pp. 996-1001, Oct. 1990.
- The current density from the electrical stimulator can exceed 2mA rms/cm^2 depending on the dimensions of the electrode, pulse width, intensity and rate of pulses of stimulation. If the electrical stimulator is used in the setting of over

2mA rms/cm² of current density, particular attentiveness by the operator is required as the stimulation may cause skin burn.

2005-07. *Effects of current on human beings and livestock Part 1. IEC Technical Specification; TS60479-1 (4th edition).*

- With current densities over 1A/cm², tissue damage is possible for long stimulation durations. To avoid current densities over 1A/cm² stimulation parameters must be carefully checked in relation to the exposed electrode surface.
Leitgeb, N. (2010). Safety of Electromedical Devices. Vienna: Springer
- A polluted device is a potential safety hazard, therefore the g.Estim PRO and its accessories and components have to be cleaned in regular intervals according to the respective instructions given in the Instructions For Use.
- Electrical cortical stimulation can evoke seizures (10.1% risk of intraoperative seizures). It is required to perform stimulation under the supervision of an expert physician and recommended to simultaneously monitor EEG signals next to the stimulation sites.
- The device can be harmful when used for longterm stimulation. Damage occurs when more than 1.26 million pulses are applied. The neural damage model: $\log(D) = k - \log(Q) \dots k \sim 1.85$. Q is charge per phase, D is charge density per phase. R. V. Shannon, "A model of safe levels for electrical stimulation," Biomedical Engineering, IEEE Transactions on, vol. 39, no. 4, pp. 424–426, 1992.
- All elements (except the electrodes) are in contact only with the operator(s). No elements of the g.Estim PRO or its accessories and components must have contact with a patient.
- A charge density per phase of less than 50µC/cm² is considered as safe (McCreery, et al. 1990). A charge density per phase above 50µC/cm² and below 150µC/cm² has a potential risk to cause damage to the stimulated tissue. A charge density per phase above 150µC/cm² can damage the stimulated tissue.
- Also electrodes from other manufacturers that are similar to the electrodes suggested in this document can be used. However it is required that all electrodes that are used with the g.Estim PRO must be cleared/certified for stimulation by a notified body in the country of use (e.g. FDA in the US, CE medical device certification in the EU).
- Before cleaning the device, it must be switched off and all cables must be unplugged.
- Cables connected to the device might be a trip hazard. Lay cables in such a way that they cannot be damaged or present a trip hazard and to minimize risk of entanglement or strangulation. Strained electrode cables are dangerous, especially for the side toward the patient. If possible, insert a strain relief for the electrode cable before it approaches the patient, and leave enough cable such that the patient is able to move freely.
- Conductible parts of all electrodes must not have contact to earth or other conductible parts.
- No cable or electrode must be connected to mains power plugs or extension cables.
- Do not connect an external power supply instead of the specified batteries.
- It is prohibited to modify the device or its components and accessories. Modification is only allowed with permission of the manufacturer. Any unqualified intervention can lead to significant impairment of functionality. Removing, opening or disassembling the device or its components and accessories may lead to health or material hazards and is prohibited. If the

device is changed, adequate investigations and tests must be conducted to ensure a safe performance.

- Only the accessories and components described in the Instructions For Use Document are allowed to be used with the device for safety reasons.
- The cortical stimulator should only be used with cortical grid, strip, depth, or hand-held ball electrodes. Usage of any other electrodes might damage the stimulated tissue.
- The device and its components and the g.tec accessories have to undergo a medical technical check once per year.
- The device does not contain any parts that can be repaired by the operator. Service and repairs may only be executed by g.tec medical engineering GmbH.
- The device is not intended to be sterilized.
- The device must be switched off during battery replacement. The person replacing the batteries must not be in physical contact with the patient.
- The g.Estim PRO and the control computer must be used within a medically used room, preferably connected to an uninterrupted power supply. The device and the computer it is connected to, as well as all the accessories and components (except electrodes and electrode connector cables) must be located outside the patient environment.
- The user of the product is responsible for any malfunction that results from improper use, faulty maintenance, improper repair, unauthorized service, or alteration by anyone other than g.tec medical engineering GmbH.
- It can only be guaranteed that the g.Estim PRO is volt-free when the USB cable is disconnected and the batteries are removed from the device.
- Usage near a short- or microwave therapy device (e.g. 1 m) can cause instabilities at the output of the electrical stimulator.
- Use of this equipment immediately adjacent to other equipment or with other equipment in a stacked configuration should be avoided as it may result in improper operation. If use in a setup described above is nevertheless necessary, this equipment and the other equipment should be observed to convince yourself that they operate properly.
- The use of accessories, transducers, and wiring other than those specified or provided by the manufacturer of this equipment may result in increased electrical emissions or decreased electromagnetic immunity of the equipment and may result in incorrect operation.
- Portable RF communications equipment (radios) (including their accessories such as antenna cables and external antennas) should not be used within 30 cm (or 12 inches) of the g.Estim PRO's parts and leads. Failure to do so may result in a reduction in the performance characteristics of the device.



CAUTION:

- The control computer must not be integrated into a network for operating the g.Estim PRO. Any active network connection or any additional software and/or hardware used in conjunction with the control computer can cause risks for the patient and/or other persons, harmful interference to the equipment or cause the equipment to fail to perform its intended function or degrade its intended performance. Therefore, before use, you must determine, analyze, assess, and mitigate those risks and assure the correct functionality of the system. If there is any undesired deviation from the intended operational performance during the

operation of the equipment, you must avoid, identify and resolve the adverse effect before continuing to use the equipment. Note that changes like the integration into a network or altering the configuration, connection or removal of elements, updates or upgrades of elements, can induce new risks and may require additional analyses.

- Electrodes must be used according to the instructions for use provided by their manufacturer.
- If the g.Estim PRO is connected to other devices, the following leakage currents must be checked.
 - Earth leakage current
 - Touch current
 - Patient leakage current
- All accessories must be used according to the instructions for use provided by their manufacturers.
- Make sure that spare batteries are available at any time.
- Pay attention to avoid electrostatic discharge impulses when connecting electrodes to the safety sockets of the device. Make sure all users and patients in contact with the device or its accessories and components are free from direct or indirect electrostatic energy before using it.
- Side effects of implanted electrodes may influence the behavioral response with respect to the stimulation.
- The device and its accessories and components must not be exposed to increased mechanical stress or to large temperature fluctuations (condensation).
- The device must be placed carefully and horizontally on a firm, flat surface to prevent falling when pulling on attached cable(s). Do not place the device on the floor or above the patient.
- The patient must be informed before usage of the cortical stimulator.
- Use the g.Estim PRO only with a personal computer according to the specification given in the Instructions For Use.
- Automatic updates of the operating system or other software installed on the computer are ideally turned off to prevent alteration of the system configuration that could potentially cause the equipment to fail to perform its intended function or degrade its intended performance. Performance settings should be set to maximum performance. Automatic sleep/hibernation/log-out/screensaver functionality should be switched off to prevent disturbances during the operation of the equipment.
- When in use, a trained medical professional must supervise the control computer.
- Before maintenance, visual inspection, cleaning or disinfection, turn the device off and disconnect all electrodes, accessories and removable components. Disconnect the USB cable from the USB socket and remove the batteries. Not following these instructions might cause electrical shock or device malfunction.
- All settings that can be edited in the user interface describe target values that are aimed to be delivered during stimulation and underlie the specified accuracies. Please refer to the Instructions for Use for the respective accuracies and tolerances.
- Accessory devices connected to the digital output of the stimulator may act upon a trigger coming from the stimulator and cause potential hazards. Therefore, before use, you must assure the correct functionality of the system without a patient connected. If there is any undesired deviation from the

intended operational performance during the operation of the equipment, you must avoid, identify and resolve the adverse effect before continuing to use the equipment. Additionally we recommend using the Foot Switch in those scenarios to be able to abort stimulation at any time.

- EEG recording devices other than g.Hlamp must be extensively tested before using any of them together with g.Estim PRO during stimulation. Errors in connecting the recording and stimulation electrodes may cause a current flow through the amplifier and (1) may cause a malfunction of the amplifier or (2) could lead to mistaken diagnosis. A g.Hlamp can be used for recording while stimulation under the following constraints:
 - Do not directly connect the g.Estim PRO to g.Hlamp
 - Do not connect the stimulation electrodes to the g.Hlamp
 - Do not stimulate and record from electrodes with an exposed diameter <1.5mm
 - Do not stimulate and record from electrodes with a spacing <5.0mm
- Stimulation must not cause >2.5V at recording electrodes
- Potential hazards to the patient resulting from stimulation of insular cortex:
 - Pain
 - Vertigo
 - Language disturbances
- Resection of brain tissue closer than 1cm to an ECS language site shows an increased risk of postsurgical language deficits.



NOTE:

- Pay attention to the precautions regarding electromagnetic compatibility described in the respective chapter in this manual.
- The g.Estim PRO has to be installed and operated according to the Instructions For Use. Cable connections have to be set up according to the Instructions For Use. Otherwise, the system may not work correctly.
- US federal law restricts the herein described device to sale by or on the order of a physician.
- Before usage of the device after transportation or storage wait until condensed water disappeared (wait at least 1h in a room according to operation conditions).
- Connecting or disconnecting cables to/from the g.Estim PRO must be done when the device is switched off, by grasping cable connectors (do not pull on wires). The person who performs wiring must not be in physical contact with the patient.
- Do not connect g.Estim PRO to the computer via a USB hub.
- Follow the installation instructions in the control software manual. Screen savers and power options of the control computer and monitor can cause safety issues and must be configured carefully. Installing system software must only be done by a qualified technician. If installation is not done correctly, the instruments might not operate in optimal capacity and may also lead to health hazards.
- For recording short triggers of the digital output socket, the recording device must acquire the data using a sufficiently high sampling rate.
- g.Estim PRO is not waterproof. Do not let any liquid get inside. Do not use volatile liquids such as thinner or benzene, because these will cause the materials to melt or crack.

- When using grid, strip, or depth electrodes, it is recommended to use imaging techniques (e.g. CT) to confirm that the electrodes are positioned properly on the target brain area.
- It is not necessary to use any tool for disconnecting the plug from the socket.
- It is recommended to use the user login service of the Microsoft Windows operating system with a strong password to authenticate users on the system where g.Estim PRO is used and to restrict access to authorized personnel only.

2.9 WARNING AND SAFETY NOTICE

It is highly recommended to carry out all adjustment, cleaning, sterilization and disinfection procedures specified in this document and in the instructions for use of the accessories.

Visual inspection of the inside of g.Estim PRO might influence its electromagnetic shielding and operation. The manufacturer does not allow disassembly of g.Estim PRO or its components and accessories, including visual inspection of the inside of the device.

2.10 INSPECTION



CAUTION:

Before maintenance, visual inspection, cleaning or disinfection, turn the device off and disconnect all electrodes, accessories and removable components. Disconnect the USB cable from the USB socket and remove the batteries. Not following this instruction, might cause electrical shock or device malfunction.

- Periodic inspection interval: 12 months
- Protection against electrical shock: Class II
- Device: portable
- Applied part type: BF

The periodic inspection of the g.Estim PRO (and accessories) is to be done according to the EN62353:2014 and chapter 7 (Technical specifications) of the IFU.

The periodic check is to be performed due to the regulated inspection steps. These are to be done consecutively. They are shortly described in the table below.

Maintenance and calibration is essential during the lifetime of g.Estim PRO device. Therefore this device must receive expert, professional attention. For this reason we recommend to simply contact your g.tec representative for more information.

Please keep in mind that if during the inspection one or more severe defects are detected or when the device is not working properly, it must not be used, must be taken out of order and marked as non-working device before it is sent for reparation.

The manufacturer is responsible for safety, performance and reliability of the device under the condition as supplied to the customer at the time of delivery and

- if changes are performed by the manufacturer only and service and repair is performed by corresponding qualified personnel only.
- the device is used according to the instruction for use.

Inspection Check	Details
	According to the EN 62353, Chapter 5.2
Visual Inspection	<p>Special attention during the outer visual inspection is to be given to following points:</p> <ul style="list-style-type: none"> • IFU available, intact, no pages missing • Condition of the housing in general (cracks, dirt, damage) • Labels on all items available and intact (graphical symbols and warnings, serial number etc.) • Battery case intact • Connectors: no damage, nuts fastened well • LEDs: all available, no damage • Anti-slip feet at the bottom of the device available and intact • Cables: no damage, connectors, sleeves and labels intact. • Hand/foot switch: no damage, connectors, sleeves and labels intact.
Measurement of safety parameters	According to the EN 62353, Chapter 5.3

Function Check	Details
Safety important output parameter I	<p>According to the EN 62353, Chapter 5.4</p> <p>The safety related functions of the equipment shall be tested according to g.tec recommendations shown below. If necessary with the assistance of a person familiar with the use of the g.Estim PRO.</p>
Subject of inspection: Electrical stimulator device with accessories	<p>Run a self-test and check if buzzer audible and all LED are working. Afterwards check following device performance according to chapter technical specification of g.Estim PRO:</p> <ul style="list-style-type: none"> • Stimulation current phase amplitude • Stimulation rate • Stimulation output voltage • Phase duration • Pulse shape • Impedance measurement and 'High Impedance' recognition • Battery state measurement • Digital in-/and output functionality • Hand-/Foot switch functionality



WARNING:

It is prohibited to modify the device or its components and accessories. Modification is only allowed with permission of the manufacturer. Any unqualified intervention can lead to significant impairment of functionality. Removing, opening or disassembling the device or its components and accessories may lead to health or material hazards and is

prohibited. If the device is changed, adequate investigations and tests must be conducted to ensure a safe performance.



WARNING:

The user of the product is responsible for any malfunction that results from improper use, faulty maintenance, improper repair, unauthorized service, or alteration by anyone other than g.tec medical engineering GmbH.



WARNING:

The device and its components and the g.tec accessories have to undergo a medical technical check once per year.



WARNING:

The device does not contain any parts that can be repaired by the operator. Service and repairs may only be executed by g.tec medical engineering GmbH.

2.11 INTERFERENCE

g.Estim PRO complies the standard for electromagnetic compatibility for medical electrical equipment (IEC 60601-1-2). If the environment in which the device is used exceeds the limits given in the standard, harmful interference can degrade its intended functionality. If any undesired deviation from the intended operational performance is noticed during the operation of the g.Estim PRO, you must avoid, identify and resolve the adverse effect before you continue using the device.

In the following points some common interference sources and mitigations are listed:

1. Electromagnetic interference from a nearby emitter source such as a radio station or cellular phone or interference with a radio wave receiver such as radio or television:
Turn off the emitter/receiver or move either the g.Estim PRO or the emitter/receiver away from each other.
2. Radio-frequency interference from other equipment through the AC power supply of the control computer:
Remove the source of the interference if possible or use a different power supply for the control computer.
3. Direct or indirect electrostatic discharge:
Make sure all users and patients in contact with the device or its accessories and components are free from direct or indirect electrostatic energy before using it.
4. Interference of lightning:
When lightning occurs near the location where the device is installed, it may induce an excessive

voltage into the system. Disconnect the AC power cord from the control computer and operate by battery power, or use an uninterruptible power supply.

5. Use with other equipment:

When the g.Estim PRO is placed adjacent to other equipment, unwanted mutual interference may occur. Before use, check that all equipment operates normally.

6. Use of unspecified accessory, cable, or other devices:

When unspecified accessories, cables, or other devices are connected to the g.Estim PRO, the system may cause increased electromagnetic emission or decreased electromagnetic immunity. The herein specified configurations of the g.Estim PRO complies with the electromagnetic requirements, so only use specified configurations.

If the suggested mitigation actions do not solve your problem, consult g.tec medical engineering for additional suggestions.



WARNING:

Usage near a short- or microwave therapy device (e.g. 1 m) can cause instabilities at the output of the electrical stimulator.

3 INTRODUCTION TO g·ESTIM PRO

The g·Estim PRO is a programmable constant-current stimulator that can deliver electrical pulses with alternating polarities, lengths, amplitudes as well as trains of such pulses intended for electrical stimulation of neural tissue. The device includes an impedance check and measures the actual stimulation current. The stimulator is controlled via software that uses a USB connection. g·Estim PRO has an applied part of type BF with connectors for bipolar stimulation electrodes (anode and cathode). The applied part is galvanic-isolated. The stimulator is powered by a combination of USB bus-power and battery power. A hand or foot-switch allows to enable the stimulation or to perform the stimulation manually. The digital output can be used to precisely synchronize stimulation timing with other devices.



HIGHLIGHTS

- Delivers bi-phasic constant current pulses
- Stand-alone device that can be controlled from a computer system
- Includes electrode impedance check and stimulation current control
- Can send triggers to other devices for synchronization

For technical specifications, please refer to chapter 5.

4 TERMINOLOGY

4.1 COMMON TERMS

ACCESSORY

Stand-alone device/part that can be used together with the g.Estim PRO that is merchandized by g.tec medical engineering GmbH or third-party companies.

COMPONENT

Device/part that is (optionally) included in the delivery, and can be used together with the g.Estim PRO. Not merchandized as stand-alone device, but available from g.tec medical engineering GmbH as supplement after purchase or as spare part in case of defect.

4.2 STIMULATION PARAMETERS

This section describes the basic terminology used in connection with the g.Estim PRO. A pulse can consist of one or two **PHASES** and an optional **INTER-PHASE DURATION** interval. The **PULSE ONSET INTERVAL** describes the whole interval from the start of one pulse to the onset of the following pulse. One or more **PULSES** form a **TRAIN**.

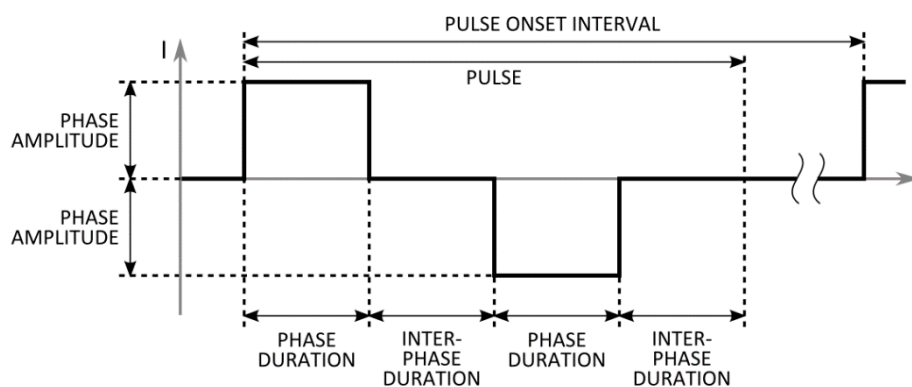


Illustration of a biphasic PULSE

PHASE

A single stimulation phase has a certain **PHASE DURATION** and **PHASE AMPLITUDE**. g.Estim PRO supports rectangular phase shapes. The **PHASE AMPLITUDE** describes the target current aimed to be delivered during stimulation. The **PHASE POLARITY** is either positive or negative, leading to I_{stim} or $-I_{stim}$ mA.

PULSE

A **PULSE** consists of one **PHASE** in monophasic mode or of two reversely polarized **PHASES** in biphasic mode and a specific **INTER-PHASE DURATION**.

INTER-PHASE DURATION

The time between the **PHASES** of one **PULSE**. In monophasic mode the **INTER-PHASE DURATION** is set to zero. In biphasic mode, the **INTER-PHASE DURATION** after the second **PHASE** serves as a minimum time between **PULSES**.

PULSE MODALITY

Either monophasic or biphasic. Monophasic **PULSES** contain one stimulation **PHASE**, biphasic **PULSES** contain two **PHASES** with different **PHASE POLARITY**.

PULSE POLARITY

Either steady or alternating. With steady **PULSE POLARITY** the **PHASE POLARITIES** within a **PULSE** always stay the same within a **TRAIN**. With alternating **PULSE POLARITY** the **PHASE POLARITIES** are 'mirrored' alternatingly within the **TRAIN**.

START POLARITY

Can be either positive or negative. This is the **PHASE POLARITY** of the very first **PHASE** of a **TRAIN**. Together with **PULSE MODALITY** and **PULSE POLARITY** this determines the shape of the **TRAIN**.

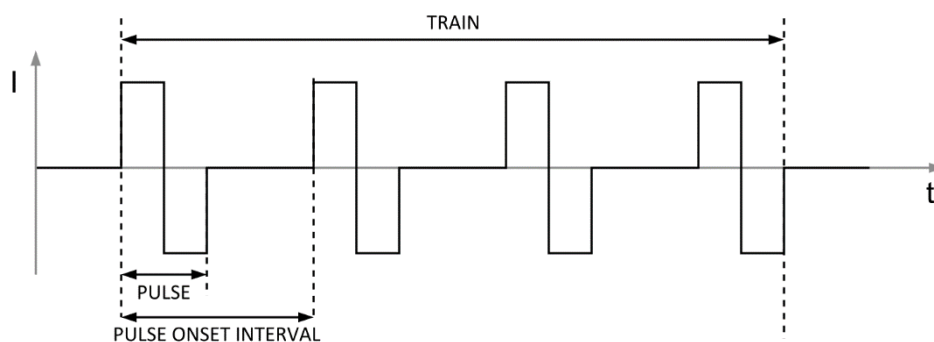


Illustration of a **TRAIN** with steady **PULSE POLARITY**

TRAIN

A **TRAIN** consists of one or more **PULSES**. Pulses are delivered either with steady or alternating **PULSE POLARITY**.

PULSE ONSET INTERVAL

The **PULSE ONSET INTERVAL** specifies the distances of the onsets of the **PULSES** within a **TRAIN**.

PULSE RATE

The **PULSE RATE** is the reciprocal of the **PULSE ONSET INTERVAL** and specifies the **PULSES** delivered per second.

5 g·ESTIM PRO SYSTEM

The g·Estim PRO system has the part number 1150 and is delivered with the items in the following table.

Quantity	Description
1	g·Estim PRO
1	USB cable
2	Trigger output cable
1	Foot switch
1	Hand switch
1	Portable case
1	Control software
1	Control software manual
1	Instructions for use
2	Battery
1	Trigger input cable

The following subsections describe the g·Estim PRO and the components and accessories that can be used with the device.



WARNING:

Only the accessories and components described in the Instructions For Use Document are allowed to be used with the device for safety reasons.



CAUTION:

All accessories must be used according to the instructions for use provided by their manufacturers.

Accessories connected to the analog and digital interfaces must be certified according to the respective IEC standards (e.g. IEC 60950 and IEC 62368-1 for data processing equipment and IEC 60601-1 for medical equipment). Furthermore, all configurations shall comply with the system standard IEC 60601-1-1. Everybody who connects additional equipment to the signal input part or signal output part configures a medical system, and is therefore responsible that the system complies with the requirements of the system standard IEC 60601-1-1. If in doubt, consult the technical service department or your local representative.



CAUTION:

If the g.Estim PRO is connected to other devices, the following leakage currents must be checked.





- Earth leakage current
- Touch current
- Patient leakage current

6 g·ESTIM PRO

6.1 LABELS, SOCKETS AND LEDS ON THE FRONT SIDE





g·Estim PRO front view

Labels	Description
+	Socket to connect the stimulation anode
-	Socket to connect the stimulation cathode
STIMULATION	LED is ON (blue) while stimulation is running
ACTIVE	LED is ON (white) when the device is ready to stimulate
HIGH IMPEDANCE	LED is ON (orange) when high impedance is detected during stimulation (i.e. when the current cannot be delivered and the highest possible voltage has been reached)
CURRENT > 10mA	LED is ON (yellow) when stimulation current is above 10mA
POWER / LOW BAT	LED is ON (green) when device is switched on and batteries are OK; LED is ON (yellow) when device is switched on and batteries have to be replaced.
HAND/FOOT SWITCH	Socket for the connection to a foot or hand-switch
	Applied part of type BF
	Attention: maximum output current can exceed +/- 10mA
	The electrostatic discharge warning symbol: electrostatic discharge impulses must be avoided when connecting cables to any of the safety sockets or push pull connectors. Follow the steps in chapter "Save operation of g·Estim PRO" to avoid electrostatic discharge impulses.
	Follow the instructions for use

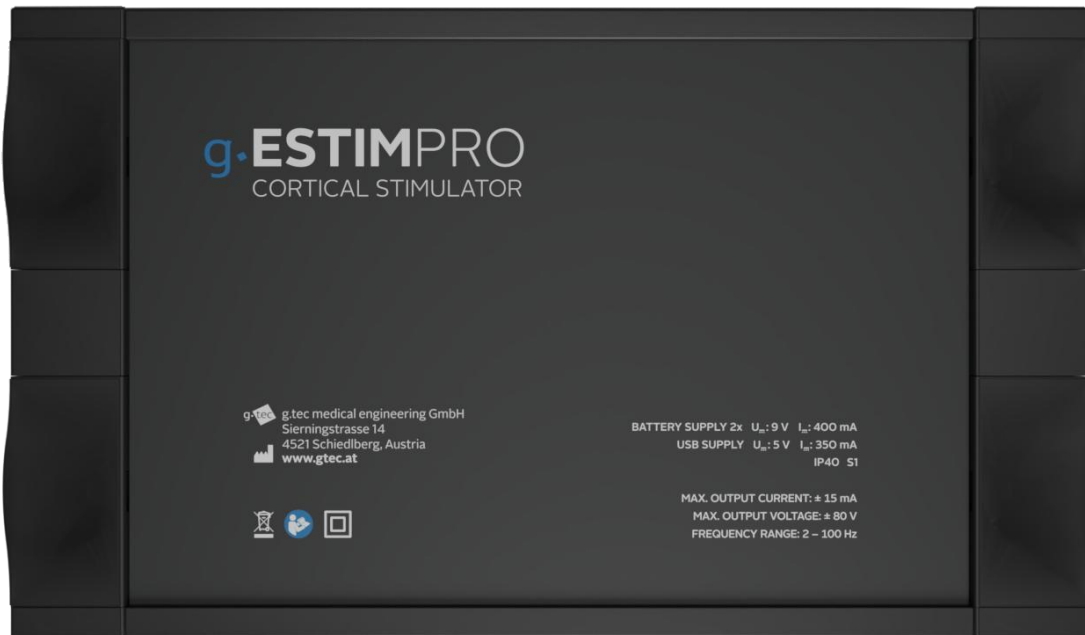
6.2 SOCKETS, SWITCH AND BATTERY HOLDERS ON THE REAR SIDE



g.Estim PRO rear view

Labels	Description
OFF/ON	Switch to power the device off/on
USB	USB socket for the connection to the computer
DI 1	Socket for digital input 1 (disabled)
DO 1	Socket for digital output 1
DO 2	Socket for digital output 2
2x 9V LITHIUM BATTERY	At the front side of the battery housing the label shows how to insert the batteries
	Inside the battery housing, in the compartments for the single batteries, another label shows how to insert the batteries.
	The electrostatic discharge warning symbol: electrostatic discharge impulses must be avoided when connecting cables to any of the safety sockets or push pull connectors. Follow the steps in chapter "Save operation of g.Estim PRO" to avoid electrostatic discharge impulses.





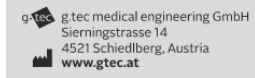

6.3 LABELS ON THE TOP SIDE



g.Estim PRO top label



g.Estim PRO bottom label

Labels	Description
	CE mark
	Do not dispose g.Estim PRO with domestic waste. Dispose it via the separate collection system for electrical and electronic equipment
	Follow the instructions for use
	Safety class II
	Manufacturer address
IP 40 S1	IP40: protected against solid objects >1.0 mm. S1: Permanent operation.
SN ES-2017.10.01	Serial number in the format ES-Year_of_production.Month.Number
REF 1150	Order number of the device
Rx only	Prescription device in the USA
BATTERY SUPPLY 2x U_{DC} : 9 V I_{DC} : 400 mA USB SUPPLY U_{DC} : 5 V I_{DC} : 350 mA	Rated DC voltage battery Rated DC current battery Rated DC voltage USB Rated DC current USB
MAX. OUTPUT CURRENT: ± 15 mA MAX. OUTPUT VOLTAGE: ± 80 V FREQUENCY RANGE: 2 – 100 Hz	Output data
+EBCI11500/\$+ES-2017.10.010	human readable form of UDI
	Unique Device Identification (UDI)

6.4 DIGITAL INPUT/OUTPUT FUNCTIONALITY

The digital input of the g.Estim PRO is disabled.

The digital outputs of the g.Estim PRO (DO 1 and DO 2) can be used to synchronize external devices like the g.Hlamp to the stimulation. In this way the information about stimulation timing can be recorded precisely in parallel to biosignal data for later analysis.

Please refer to the g.Estim PRO control software manual for more detailed information and how to operate the device with the digital output functionality.

The following devices may be connected to the digital output (DO 1 or DO 2) of the g.Estim PRO:

- g.Hlamp (g.tec medical engineering GmbH)
- g.USBamp (g.tec medical engineering GmbH)



NOTE:

For recording short triggers of the digital output socket, the recording device must acquire the data using a sufficiently high sampling rate.

6.5 USB CABLE

The USB cable is a component of the g.Estim PRO and is included in the delivery. It is a 4 wire cable used for the connection of g.Estim PRO with a PC. On the PC side a standard USB connector PC USB is used, on the g.Estim PRO side a special 8-pin push-pull connector USB is used. In case of damage the cable can be ordered from g.tec medical engineering GmbH by using the part number 1159.



Labels	Description
PC USB	USB connector to PC
"USB" or "g.tec USB"	USB connector to g.Estim PRO
g.tec	Manufacturer
1159	REF number

6.6 TRIGGER INPUT CABLE

The trigger input cable is a component of the g.Estim PRO and on request it is included in the delivery. The trigger input cable is used for contacting DI 1 of the g.Estim PRO to digital outputs of external devices. It has a length of 1 m. At one end of the cable it is equipped with a 3-pin push-pull connector (DIG IN 1) to fit into the DI 1 socket of the g.Estim PRO. On the other end it is equipped with a male BNC connector (BNC). Note that the digital input socket of g.Estim PRO is disabled. In case of damage or as supplement the cable can be ordered from g.tec medical engineering GmbH by using the part number 1150TI.



Labels	Description
BNC	BNC connector to external device
DIG IN1	Connector to g.Estim PRO
g.tec medical engineering GmbH	Manufacturer
1150TI	REF number

6.7 TRIGGER OUTPUT CABLE

The trigger output cable is a component of the g.Estim PRO and two pieces are included in the delivery. The trigger output cable is used for contacting DO 1 or DO 2 of the g.Estim PRO to external devices. It has a length of 1 m. At one end the cable is equipped with a 3-pin push-pull connector (DIG OUT) to fit into either the DO 1 or the DO 2 socket of the g.Estim PRO. On the other end it is equipped with a male BNC connector (BNC). Triggers from the DO connectors can be used to synchronize external equipment to the stimulation delivered by the g.Estim PRO. In case of damage or as supplement the cable can be ordered from g.tec medical engineering GmbH by using the part number 1150TO.



Labels	Description
BNC	BNC connector to external device
DIG OUT	Connector to g.Estim PRO
g.tec medical engineering GmbH	Manufacturer
1150TO	REF number



NOTE:

For recording short triggers of the digital output socket, the recording device must acquire the data using a sufficiently high sampling rate.

6.8 PORTABLE CASE

The g.Estim PRO comes in a water-proof packaging. Use always this case for storage and transportation. In case of damage the carrying case can be ordered from g.tec medical engineering GmbH by using the part number 1158. The pictures in the second row show the labels that are attached to the case for identification of the devices.



Labels	Description
	Manufacturer identification
	Product identification

6.9 FOOT SWITCH

The foot switch is an accessory of the g.Estim PRO and is included in the delivery. Connect the foot switch to the HAND/FOOT SWITCH input of the g.Estim PRO. When the foot switch is used and pressed, the stimulator accepts a cue to start stimulation from the software or from devices connected to the digital input ports. When the foot switch is released, stimulation is aborted. For further information, please refer to the instructions for use of the foot switch. The foot switch can be ordered from g.tec medical engineering GmbH by using the part number 1150FS.



Labels	Description
g.Estim Hand/Foot switch	Connector to g.Estim PRO
	Type code Maximum current (3 A) / voltage (24 V) switchable ratings and IP rating SN: Serial number (YYYYMMNN: Y year; M month; NN: increasing number) Contact info manufacturer
	UL Recognized Component Mark
	Safety class II
	CE mark

6.10 HAND SWITCH

The hand switch is an accessory of the g.Estim PRO and is included in the delivery. Connect the hand switch to the HAND/FOOT SWITCH input of the g.Estim PRO. The hand switch allows users to start stimulation by pressing the STIMULATE button after the device has been set active via the software and the 'ACTIVE' LED is on. During stimulation, it allows users to abort stimulation by pressing the ABORT button. The hand switch can be ordered from g.tec medical engineering GmbH by using the part number 1150HS.



Labels	Description
g.Estim Hand/Foot switch	Connector to g.Estim PRO
	<p>Label with part name (HAND SWITCH), part number (REF) and serial number (SN, YYYYMMNN: Y year; M month; NN: increasing number)</p> <p>Maximum current (1 A) / voltage (24 V) switchable ratings and IP rating</p>
	Contact information manufacturer
	CE mark
	<p>STIMULATE marks the button to start stimulation</p> <p>ABORT marks the button for aborting stimulation</p>

6.11 COMPUTER

For operation of the g.Estim PRO a PC compatible desktop, notebook workstation or embedded computer running a Microsoft Windows operating system according to the specification below is required. The computer is not included in delivery. While using g.Estim PRO, full power to the PC USB connectors has to be guaranteed. Therefore, do not use any power saving mode. Directly connect the USB connector to the computer. For further information, please refer to the instructions for use of the computer.



CAUTION:

The control computer must not be integrated into a network for operating the g.Estim PRO. Any active network connection or any additional software and/or hardware used in conjunction with the control computer can cause risks for the patient and/or other persons, harmful interference to the equipment or cause the equipment to fail to perform its intended function or degrade its intended performance. Therefore, before use, you must determine, analyze, assess, and mitigate those risks and assure the correct functionality of the system. If there is any undesired deviation from the intended operational performance during the operation of the equipment, you must avoid, identify and resolve the adverse effect before continuing to use the equipment. Note that changes like the integration into a network or altering the configuration, connection or removal of elements, updates or upgrades of elements, can induce new risks and may require additional analyses.

Hardware	Properties
CPU	Intel, 2 cores (or more) at 2.30 GHz (or higher)
Harddisk	> 100 GB
RAM	8 GB
USB 3.0 port	one free USB port for g.Estim PRO

OTS Software	Properties
Operating System	Windows 11 Pro, 64-bit, version 23H2
.NET framework**	4.8
Microsoft Visual C++ Redistributable *	2015-2022
g.Estim PRO driver *	Version 1.24.00.01

* Software is included in the g.Estim PRO Installation package.

** Part of the Operating System

6.12 TRADEMARK NOTICE

Windows is a registered trademark of Microsoft Corporation in the United States and other countries. All brands or product names are the property of the respective owners.

**CAUTION:**

Use the g.Estim PRO only with a personal computer according to the specification given in the Instructions For Use.

**NOTE:**

Do not connect g.Estim PRO to the computer via a USB hub.

**NOTE:**

Follow the installation instructions in the control software manual. Screen savers and power options of the control computer and monitor can cause safety issues and must be configured carefully. Installing system software must only be done by a qualified technician. If installation is not done correctly, the instruments might not operate in optimal capacity and may also lead to health hazards.

6.13 BATTERY

The g.Estim PRO has to be operated using lithium batteries from Energizer Holdings, Inc., MO, USA (product number: L522) or Ultralife Corporation, NY, USA (product number: U9VL-J-P). Two batteries are included in the delivery of the g.Estim PRO. They can be ordered from g.tec medical engineering GmbH using the part number B0004. For further information, please refer to the instructions for use of the batteries.

**WARNING:**

Do not connect an external power supply instead of the specified batteries.

6.14 STIMULATION ELECTRODES

Stimulation electrodes are used as medium between the stimulator and the tissue to be stimulated. They are not included in delivery and can be ordered from specialized electrode manufacturers as described below.

**WARNING:**

The cortical stimulator should only be used with cortical grid, strip, depth, or hand-held ball electrodes. Usage of any other electrodes might damage the stimulated tissue.

6.14.1 GRID/STRIP ELECTRODES

The manufacturer recommends using grid or strip electrodes from Ad-Tech Medical Instrument Corporation, WI, USA with the following diameters:

Diameter (mm)	Exposure diameter (mm)	Exposed stimulation area (mm ²)	Number of example product Ad-Tech
4.00	2.30	4.155	FG20C-SP10X-000 (4x5 grid)
4.00	1.80	2.545	TS04R-AP10X-0W6 (1x4 strip)
6.00	5.00	19.635	MS08R-IP10X-000 (1x8 strip)

The exposed stimulation area is calculated using the formula for the area of circles:

$$A = \pi r^2$$

where r is the radius of the exposed area in mm (i.e. the exposed diameter divided by 2) and A is the resulting exposed stimulation area in mm².

6.14.2 DEPTH ELECTRODES

The manufacturer recommends using depth electrodes from Ad-Tech Medical Instrument Corporation, WI, USA with the following diameters:

Diameter (mm)	Contact length (mm)	Exposed stimulation area (mm ²)	Number of example product Ad-Tech
1.12	2.41	8.480	SD10R-SP05X-000 (10 contact depth electrode)
1.12	1.32	4.645	SD08R-AP58X-000 (8 contact depth electrode)
1.96	1.27	7.820	AD04R-SP10X-000 (4 contact depth electrode)
0.86	2.29	6.187	RD10R-SP08X-000 (10 contact depth electrode)
1.02	2.42	7.723	FO04K-SP05X-000 (4 contact depth electrode)

The exposed stimulation area is calculated using the formula for the side area of cylinders:

$$A = 2\pi rh$$

where r is the radius of the electrode in mm (i.e. the diameter divided by 2), h is the contact height in mm, and A is the resulting exposed stimulation area in mm².

6.14.3 HAND-HELD ELECTRODES

The manufacturer recommends using a disposable hand-held stimulation probe from Natus Medical Inc., CA, USA, part no. 222-496100, with an electrode ball diameter of 2.2 mm, which leads to an exposed stimulation area of 7.603 mm² per electrode (half of the balls surface). The spacing between the electrodes is 5 mm.

The exposed stimulation area is calculated using the formula for the area of a sphere:

$$A = 4\pi r^2$$

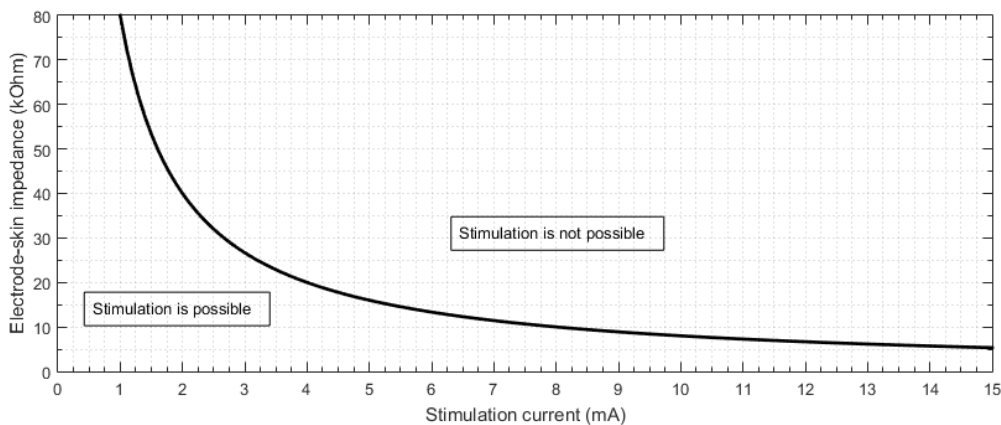
where r is the radius of the electrode ball in mm (i.e. the diameter divided by 2) and A is the resulting surface of the ball. It is assumed that only the lower hemisphere of the ball is contacting the tissue during stimulation, so the resulting area A is divided by 2.



NOTE:

Tables containing the maximum output values for different electrode sizes can be found in Appendix D – Current density tables.

The maximum current that can be delivered by the g.Estim PRO is depending on the electrical impedance between the tissue and the electrode. For any given stimulation output current the impedance must be below the threshold given in the following figure. The tissue-electrode impedance can be measured using the respective functionality of the g.Estim PRO Software.



Threshold for electrode-tissue impedance depending on the requested stimulation current

It is recommended by the manufacturer that stimulation is generally done with an electrode-tissue impedance $< 5 \text{ k}\Omega$.



WARNING:

Electrodes from other manufacturers that are similar to the electrodes suggested in this document can be used. However, it is required that all electrodes that are used with the g.Estim PRO must be cleared/certified for stimulation by a notified body in the country of use (e.g. FDA in the US, CE medical device certification in the EU).



CAUTION:

Electrodes must be used according to the instructions for use provided by their manufacturer.



CAUTION:

When using grid, strip, or depth electrodes, it is recommended to use imaging techniques (e.g. CT) to confirm that the electrodes are positioned properly on the target brain area.

6.14.4 ELECTRODE CONNECTOR CABLE

An electrode connector cable is used for connecting the stimulation electrodes to the g.Estim PRO. Electrode connector cables are not included in delivery of g.Estim PRO and can be ordered from specialized electrode manufacturers as described below.

The manufacturer recommends to use an electrode connection system from Ad-Tech Medical Instrument Corporation, WI, USA from the table below as appropriate for the used electrodes.

Ad-Tech product number prefixes	Description
L-SRL-*	Lightweight CABRIO® connector/cable
L-DCL-*	Lightweight TECH-ATTACH cable
L-SRL-*-10	Lightweight CABRIO connector/cable for quick disconnect
L-DCL-*-10	Lightweight TECH-ATTACH cable for quick disconnect

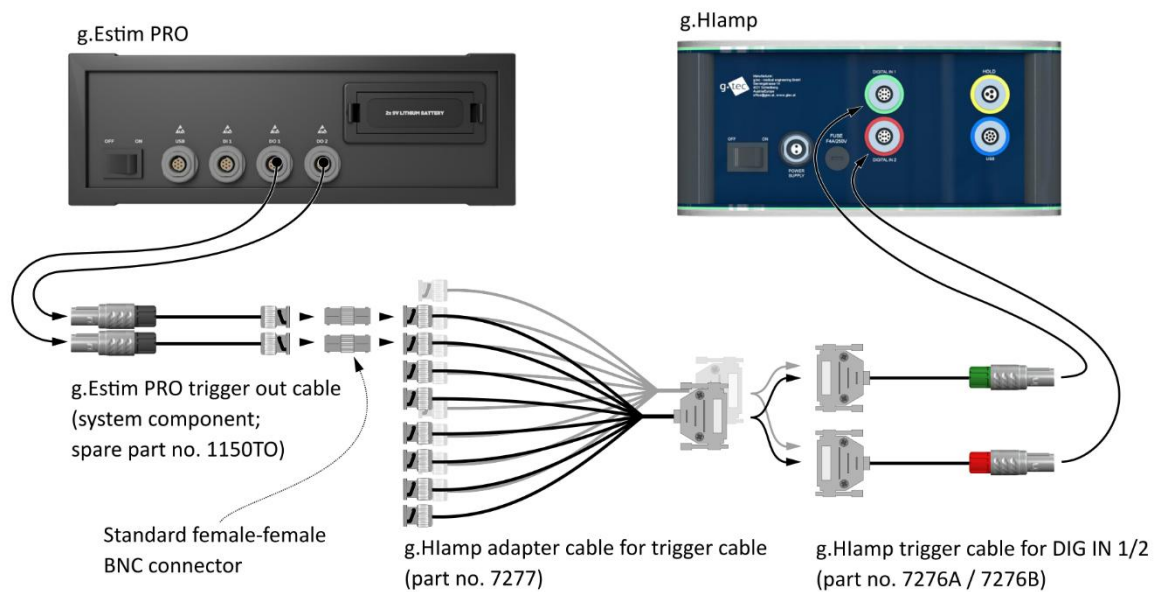
It is recommended to use a minimum cable length of 1.8m. For further important information, please refer to the instructions for use of the electrode connector cable.

6.15 g.HIAMP

The g.HIamp (g.tec medical engineering GmbH, part no. 7091US/7092US/7001US/7002US/7003US) is a biosignal amplifier with 16/32/80/144/256 analog input channels. The data is converted to a 24 bit digital signal that is transmitted via USB for storage or processing on a computer. The device can be used to record electroencephalographic (EEG), electrocorticographic (ECoG), electrocardiographic (ECG) or other electrophysiological signals. The g.HIamp has 16 digital input channels that are recorded synchronously to the biosignals. With this functionality stimulation events can be recorded in parallel to the biosignals for analysis. The g.HIamp is not included in the delivery of the g.Estim PRO. For further information, please refer to the instructions for use of the g.HIamp.

The g.HIamp has two digital input sockets at the rear side of the device. To those sockets a g.HIamp trigger cable for DIG IN 1 or DIG IN 2 (accessory of the g.HIamp, part no. 7276A or 7276B) can be connected. Those cables end with D-SUB plugs that can be connected to g.HIamp adapter cables for trigger cable (accessory of g.HIamp, part no. 7277). Those cables end with eight male BNC sockets each. To connect the digital output of the g.Estim PRO to the digital input of the g.HIamp one or two g.Estim PRO trigger out cables (part of the g.Estim PRO) can be connected to the g.HIamp trigger adapter cable(s) using standard BNC female to female connectors.

BNC female to female connectors from Amphenol Corporation (part no. B7071A1-ND3G-75) are recommended.



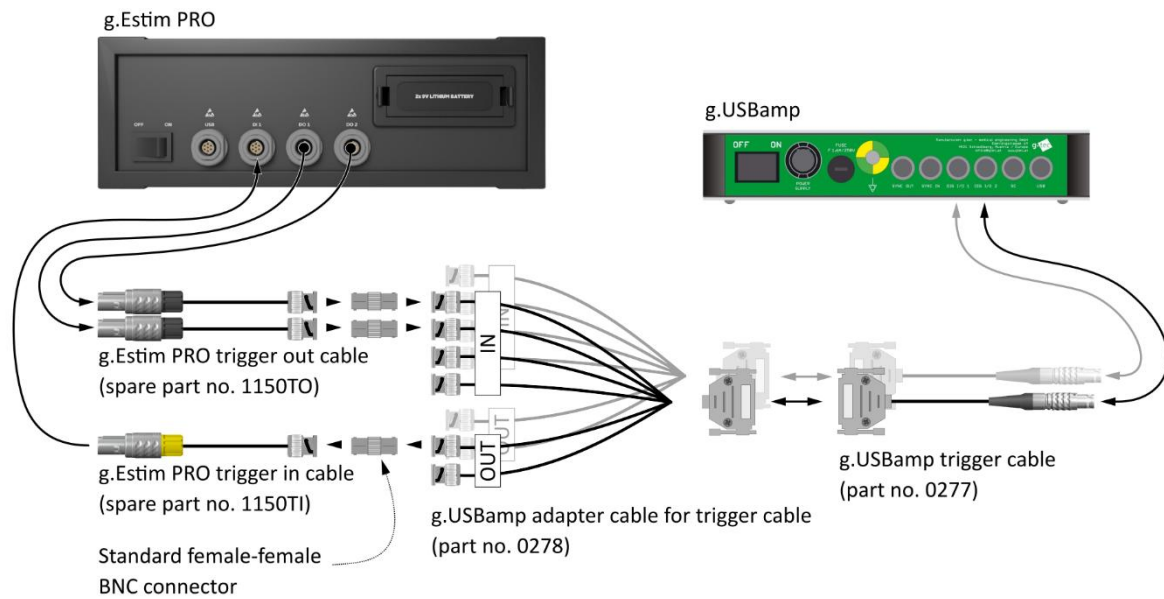
Connecting g.Estim PRO digital output to the g.Hlamp digital input

6.16 g.USBAMP

The g.USBamp (g.tec medical engineering GmbH, part no. 0216) is a biosignal amplifier with 16 analog input channels. The data is converted to a 24 bit digital signal that is transmitted via USB for storage or processing on a computer. The device can be used to record electroencephalographic (EEG), electrocorticographic (ECoG), electrocardiographic (ECG) or other electrophysiological signals. The g.USBamp has eight digital input channels and four digital output channels. The digital input channels are recorded synchronously to the biosignals. With this functionality stimulation events can be recorded in parallel to the biosignals for analysis. The g.USBamp is not included in the delivery of the g.Estim PRO. For further information, please refer to the instructions for use of the g.USBamp.

The following figure shows how the g.Estim PRO and the g.USBamp can be connected together.

The g.USBamp has two digital input/output sockets. To each of those sockets a g.USBamp trigger cable (accessory of the g.USBamp, part no. 0277) can be connected. Those cables end with D-SUB plugs that can be connected to g.USBamp adapter cables for trigger cable (accessory of g.USBamp, part no. 0278). Those cables end with male BNC sockets, four for digital input and two for digital output each. To connect the digital output of the g.Estim PRO to the digital input of the g.USBamp one or two g.Estim PRO trigger out cables (part of the g.Estim PRO) can be connected to digital input lines of the trigger adapter cable using standard BNC female to female connectors. BNC female to female connectors from Amphenol Corporation, part no. B7071A1-ND3G-75, are recommended.



Connecting g.Estim PRO digital output to the g.USBamp digital input



CAUTION:

Accessory devices connected to the digital output of the stimulator may act upon a trigger coming from the stimulator and cause potential hazards. Therefore, before use, you must assure the correct functionality of the system without a patient connected. If there is any undesired deviation from the intended operational performance during the operation of the equipment, you must avoid, identify and resolve the adverse effect before continuing to use the equipment. Additionally, we recommend using the Foot Switch in those scenarios to be able to abort stimulation at any time.

7 SAFE OPERATION OF g·ESTIM PRO

7.1 SETUP

Step 1: Avoid electrostatic discharge

Electrostatic discharge (ESD) events can harm electronic components inside your device. Under certain conditions, ESD may build up on your body or an object, such as a peripheral, and then discharge into another object, such as the device. To prevent ESD damage, you should discharge static electricity from your body before you interact with any part of your device. You can protect against ESD and discharge static electricity from your body by touching a metal grounded object. When connecting the electrodes to the device, you should always ground yourself to remove any static charge your body may have accumulated.

**CAUTION:**

The device must be placed carefully and horizontally on a firm, flat surface to prevent falling when pulling on attached cable(s). Do not place the device on the floor or above people.

Step 2: System Check

In order to ensure safe operation of the g·Estim PRO and its components and accessories, it is mandatory to ensure that the equipment is in good condition. Therefore, the following checks have to be performed before the device is switched on:

- Visually inspect all the components, accessories, cables, and connections to other devices in order to identify any indication of failure, damage, pollution, moisture, or disconnection
- verify that all labels and signs printed on the device are readable
- verify that enough charged spare batteries are available
- verify that all necessary components and accessories are available
- verify also that the control computer and its accessories (like mouse, keyboard, monitor and power supply) are in proper condition

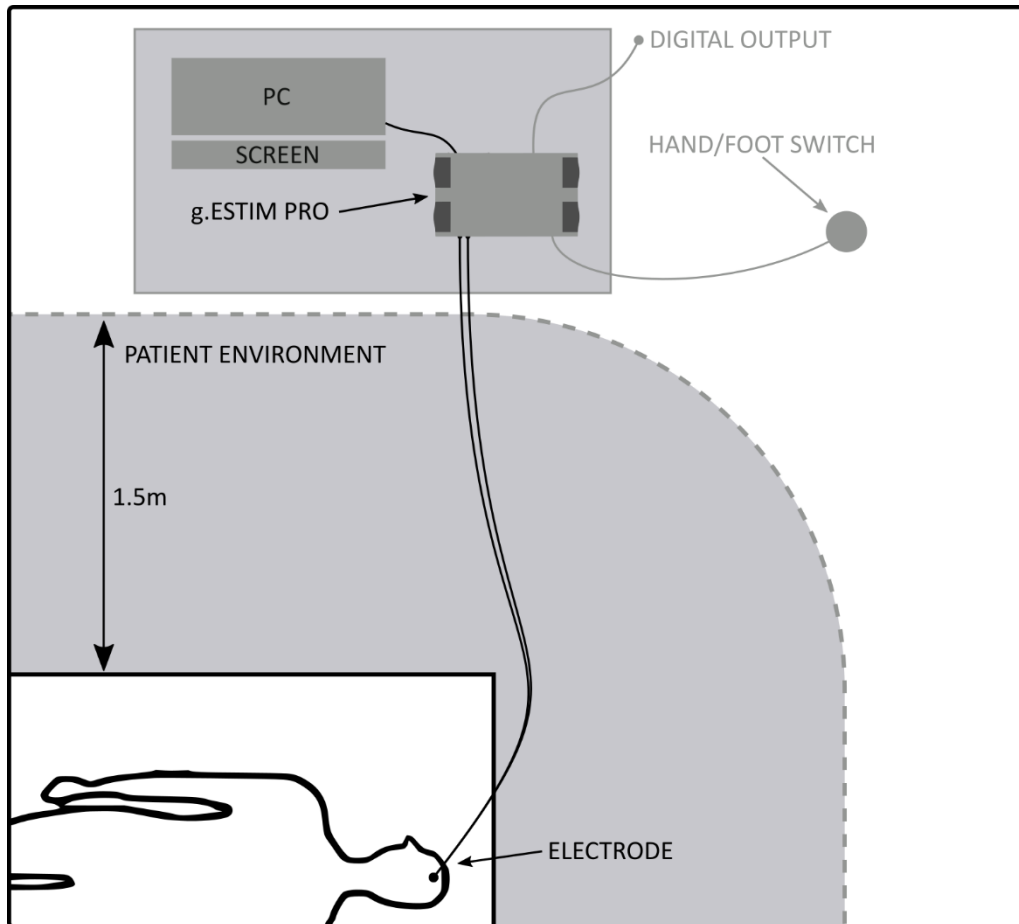
**NOTE:**

To cut off the power supply to the g·Estim PRO and stop stimulation, disconnect the USB cable from the back side of the device and remove the batteries. When installing the g·Estim PRO, make sure that the plug is easily accessible.

**WARNING:**

It can only be guaranteed that the g·Estim PRO is volt-free when the USB cable is disconnected and the batteries are removed from the device.

Place the g·Estim PRO outside the patient environment as shown in the following figure.



NOTE:

The foot switch can be placed on the floor underneath the patient in the operating room, which must not be accessible by the patient.



WARNING:

The g·Estim PRO and the control computer must be used within a medically used room, preferably connected to an uninterrupted power supply. The device and the computer it is connected to, as well as all the accessories and components (except electrodes and electrode connector cables) must be located outside the patient environment.



WARNING:

All elements (except the electrodes) are in contact only with the operator(s). No elements of the g·Estim PRO or its accessories and components must have contact with a patient.



WARNING:

Cables connected to the device might be a trip hazard. Lay cables in such a way that they cannot be damaged or present a trip hazard and to minimize risk of entanglement or strangulation. Strained electrode cables are dangerous, especially for the side toward the patient. If possible, insert a strain relief for the electrode cable before it approaches the patient, and leave enough cable such that the patient is able to move freely.

7.2 START

Step 1: Connect g.Estim PRO to the computer with the USB cable.

Connect the following components and/or accessories if required for the session: foot or hand switch, trigger out cables.

Step 2: Switch on g.Estim PRO (switch position ON) and check the following points:

- verify that there is no fire, smoke or odor, and that the surfaces of the device do not get hot or electrically charged
- verify that the device does not affect surrounding equipment
- the LED POWER is ON in green
- If the LED POWER is not ON, please check the USB connection. If the LED POWER is ON in yellow, please switch the device off and change the batteries.

Step 3: Start the Control software.

When the software connects to the stimulator, it executes a self-test. During the self-test, verify that the buzzer can be heard and that the indication LEDs work correctly. The self-test must be performed successfully to proceed. If the test failed, the device is locked and the manufacturer has to be contacted. After the self-test is successfully passed, select an operation mode according to the procedure you want to perform. For details, please refer to the Control software manual.

Step 4: Connect electrode probe to the stimulation output of the g.Estim PRO.

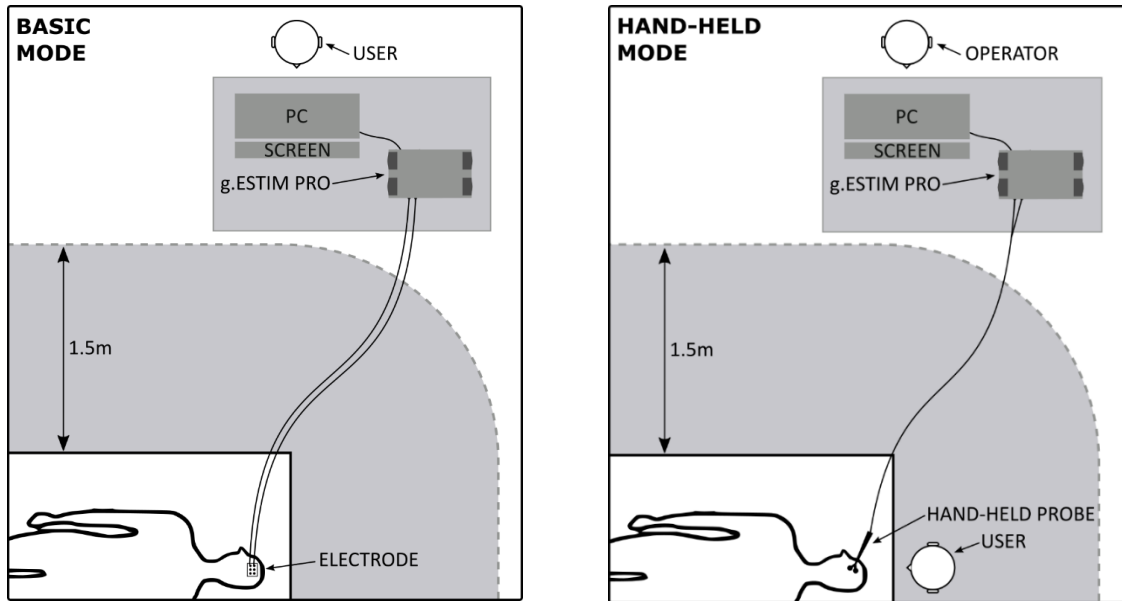
For subdural or depth electrodes follow Step 5.1 and for hand-held electrode probes follow Step 5.2.

Step 5.1 (BASIC mode): Electrodes must be implanted by a neurosurgeon either prior to the usage of the stimulator and further connected to an adapter that provides 1.5 mm touch-proof connectors according to the instructions for use of the manufacturer.

For such electrodes use the "Basic ECS mode" and enter the diameter of the smallest electrode in the Control software that will be used for stimulation.

Step 5.2 (HAND-HELD mode): Connect the 1.5 mm touch-proof connectors of the sterilized hand-held electrode probe to the stimulation output of the g.Estim PRO.

Make sure to not contaminate the hand-held electrode probe and follow the instructions for use of the manufacturer. For such an electrode the "Hand-held mode" must be used in the Control software and the diameter of the electrode tip must be entered.



In basic mode with implanted electrodes, the user can operate the g·Estim PRO control software and start/stop the stimulation via software or hand-switch. In hand-held mode, the user holds the sterile hand-held probe and needs another person to operate the g·Estim PRO control software.



WARNING:

Conductible parts of all electrodes must not have contact with earth or other conductible parts.



WARNING:

No cable or electrode must be connected to mains power plugs or extension cables.



CAUTION:

Stimulation must not be applied with electrodes that are not in accordance with the specification of the g·Estim PRO.



CAUTION:

Side effects of implanted electrodes may influence the behavioral response with respect to the stimulation.



CAUTION:

Pay attention to avoid electrostatic discharge impulses when connecting electrodes to the safety sockets of the device. Make sure all users and patients in contact with the device or its accessories and components are free from direct or indirect electrostatic energy before using it.

Step 6: Perform the necessary stimulation settings with the software that uses g.Estim PRO.
The LED ACTIVE shows that the device is properly configured for stimulation.



CAUTION:

The patient must be informed before usage of the cortical stimulator.

During stimulation, the **LED STIMULATION** will indicate when the device is stimulating, the **LED HIGH IMPEDANCE** will indicate that the device could not deliver the requested output current and therefore aborted stimulation (e.g. if the electrodes don't have proper contact to the tissue), and the **LED CURRENT>10mA** will indicate if the configured stimulation current exceeds 10 mA.
When stimulating with the g.Estim PRO, keep the following instructions in mind:

- Do not place the electrodes above irritated tissue or locations with reduced sensibility.
- Avoid incidental contact of the electrodes with the cortical surface – place the electrodes carefully.
- Ensure that the stimulation electrodes are in good contact with the cortical tissue.
- Start stimulation after the electrodes are in good contact with the tissue.
- Stimulate first with the lowest current level and slowly increase in small steps until there is a physiological response.
- Stimulate at current levels that do not evoke after-discharges.
- Stop stimulation immediately if the patient does not feel well or an unexpected reaction appears.



CAUTION:

Electrical stimulation can influence electrical monitoring equipment (e.g. electroencephalographic or electrocardiographic acquisition systems) if they are connected to the patient at the same time.



CAUTION:

When in use, a trained medical professional must supervise the control computer.

7.3 RECORDING INTRACRANIAL EEG WHILE STIMULATING

Step 1: Connect a g.Hlamp (g.tec medical engineering GmbH) biosignal amplifier to the control computer.

Step 2: Start the recording software (such as g.Hsys Professional or g.Recorder) to visualize and store raw data.

Step 3: Connect the recording electrodes, but not the stimulation electrodes, to the g.Hlamp. Select a proper GND electrode, which cannot be any of the stimulation electrodes.

Step 4: If necessary, connect the digital output of the g.Estim PRO to the digital input of the g.Hlamp according to section 3.12.



CAUTION:

If the g.Estim PRO is connected to other devices, the following leakage currents must be checked.

- Earth leakage current
- Touch current
- Patient leakage current



CAUTION:

EEG recording devices other than g.Hlamp must be extensively tested before using any of them together with g.Estim PRO during stimulation. Errors in connecting the recording and stimulation electrodes may cause a current flow through the amplifier and (1) may cause a malfunction of the amplifier or (2) could lead to mistaken diagnosis. A g.Hlamp can be used for recording while stimulation under the following constraints:

- Do not directly connect the g.Estim PRO to g.Hlamp
- Do not connect the stimulation electrodes to the g.Hlamp
- Do not stimulate and record from electrodes with an exposed diameter <1.5mm
- Do not stimulate and record from electrodes with a spacing <5.0mm
- Stimulation must not cause >2.5V at recording electrodes

7.4 SWITCHING OFF AND STORAGE OF g.ESTIM PRO

Step 1: Switch off the device (switch position OFF).

Step 2: Disconnect all stimulation electrodes.

Step 3: Disconnect the USB cable, accessories and removable components.

Step 4: Verify that the system is not dirty, damaged or in contact with liquid. Clean the device if necessary.

Step 5: Verify that no cable is frayed or damaged and that enough charged spare batteries are available.

Step 6: Store the device and its components and the accessories from g.tec together in the portable carry case under appropriate conditions.

For longer storage, remove the batteries from the device.



WARNING:

It can only be guaranteed that the g.Estim PRO is volt-free when the USB cable is disconnected and the batteries are removed from the device.

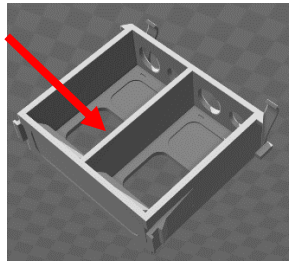
7.5 BATTERY REPLACEMENT

Step 1: Switch off the device and disconnect the electrodes from the stimulator.

Step 2: Release the battery drawer on both sides and pull out the drawer.



Step 3: Remove the empty batteries by lifting each battery with your finger towards the bottom drawer holes.



Step 4: Insert new batteries considering the correct polarity direction of the batteries.

Press them fully into the drawer. The g.Estim PRO has to be operated using lithium batteries from Energizer Holdings, Inc., MO, USA, (product number: L522) or Ultralife Corporation, NY, USA (product number: U9VL-J-P). They can be ordered from g.tec medical engineering GmbH using the part number B0004.

Step 5: Push the drawer back until both locking springs fully expand and keep the drawer in the housing.

Step 6: Connect the electrodes to the stimulator and switch the device on.



WARNING:

The device must be switched off and the electrodes must be disconnected during battery replacement. The person replacing the batteries must not be in physical contact with the patient.



CAUTION:

Make sure that spare batteries are available at any time.

8 GENERAL NOTES

8.1 CLASSIFICATION

Classification	
Protection against electrical shock	Class II
Type of applied part	BF
Protection against mechanical distortion and liquids	IP40
Operation mode	S1 (permanent operation)

8.2 TRANSPORTATION AND STORAGE CONDITIONS

The device can be stored and transported at temperatures between -20 and +60 degrees Celsius. The relative humidity must be between 10 % and 95 %. The atmospheric pressure for storage and transportation must be between 700 and 1060 hPa.

8.3 OPERATION CONDITIONS

The device can be operated at temperatures between +10 and +35 degrees Celsius. The relative humidity must be between 20 % and 80 % (non-condensing). If floors are covered with synthetic material, the relative humidity should be at least 30 %. The atmospheric pressure for operation must be between 800 and 1060 hPa.

**NOTE:**

Do not use the device near a heating system or directly in the sun.

**NOTE:**

Before usage of the device after transportation or storage wait until condensed water disappeared (wait at least 1h in a room according to operation conditions).

8.4 WASTE DISPOSAL DETAILS

When disposing the g·Estim PRO and its accessories and components at their end of life, bring the devices to a recycling center according to federal, state and local laws or send them back to the manufacturer. If there is a possibility that the device, components, accessories, or electrodes may have been contaminated with infection they might be a biohazard dispose of them as medical waste according to federal, state and local laws, your facility's guidelines for medical waste and for the electrodes, as recommended by the electrode manufacturer. After use, the batteries must be disposed of according to federal, state and local laws.

8.5 CLEANING



NOTE:

Before cleaning the device, it must be switched off and all cables must be unplugged.

Do not soak or immerse the device or its accessories or components in any liquid. Do not use petroleum based or acetone solutions, or other harsh solvents or scrubbing agents to clean the parts. Only use approved cleaning agents as stated below.

Approved cleaning and disinfection material:

Mikrozid® AF wipes #10920 for disinfection, or equal disinfection wipes, and Mikrozid® sensitive wipes #70000807 for cleaning.

Initial cleaning:

Before the system can be used in the intended areas, a cleaning and disinfection of the system is necessary.

Cleaning and Disinfection:

1. Switch off the device and unplug all connected cables.
2. Make sure that the batteries are removed and the battery case is empty.
3. Use the approved wipes to remove all visible soiling. Be sure that accessories and components are unplugged before cleaning and make sure no liquid seeps into the instrument e.g. at plugging.
4. For disinfection use a new wipe and completely bedew all surfaces of the device.
5. For all other accessories and components repeat step 3 and 4.
6. Cleaning of components must be done according to this document. Cleaning of accessories must be done according to the instructions for use of the accessory.
7. Make sure that the device and its accessories and components are completely dry before connecting with other devices, before the system is used or stored in the case.



WARNING:

The device is not intended to be sterilized.



NOTE:

g.Estim PRO is not waterproof. Do not let any liquid get inside. Do not use volatile liquids such as thinner or benzine, because these will cause the materials to melt or crack.

8.6 WARRANTY

Two-year warranty.

9 DECLARATION OF CONFORMITY

The declaration of conformity is available upon request.

10 TECHNICAL SPECIFICATIONS **g·ESTIM PRO**

Model	Details
Type	Cortical stimulator
Rated power consumption USB	1.75 VA
Rated power consumption Battery	3.6 VA
Rated voltage USB	5 V DC
Rated voltage battery	9 V DC
Fuses F1, F2, F3:	
Type	20 mm
Time-Current Characteristic	Medium Time Lag (M)
Breaking capacity	80 A / 250 VAC, 50-60Hz, $\cos \phi = 1.0$
Rated current	500 mA DC
Rated voltage	250 V AC
Produced	See serial number of g·Estim PRO
Producer	g.tec medical engineering GmbH Sierningstrasse 14 4521 Schiedlberg, Austria www.gtec.at

Maximum output voltages at the sockets	Details
D11	3.3 V DC
ELECTRODES +/-	80 V DC
HAND/FOOT SWITCH	3.3 V DC

Stimulation output	Details
Stimulation phase amplitude	0.2 – 15 mA Resolution: 10 μ A Accuracy: \pm 10 % or 50 μ A, whichever greater
Phase shape	rectangular
Train duration	1 pulse – 20 seconds
Pulse onset interval	10 ms – 500 ms
Pulse rate (per s)	2 – 100 pulses per second with a resolution of 0.1 pulses per second Accuracy: \pm 10%
Phase duration	0.1 – 1.0 ms in 10 μ s increments \pm 10 % or \pm 20 μ s whichever greater
Inter-phase duration	Always 0 ms
Power supply	2 x 9V battery USB-connection

Input voltage range at DI1 port	Details
High-level voltage range	2.0 – 5.0 V DC
Low-level voltage range	0.0 – 0.8 V DC

Voltage range at USB port	Details
Voltage range	4.75 – 5.25 V DC

Output voltage range at DO1/2 port	Details
High-level voltage range	2.4 – 3.3 V DC
Low-level voltage range	0.0 – 0.4 V DC

11 ELECTROMAGNETIC COMPATIBILITY

Electrical devices have to comply with special safety regulations regarding electromagnetic compatibility (EMC). Please keep in mind the respective precautions in this instruction for use manual before installing and operating g.Estim PRO. Pay attention to the fact that mobile HF-communication devices (e.g. mobile phones) may interfere with medical electric devices. g.Estim PRO must not be used nearby or stockpiled with other devices. Only the original components and accessories for g.Estim PRO from g.tec medical engineering GmbH are allowed to be used for this device. Using third party manufacturer accessories may result in increased emission or decreased functional immunity of g.Estim PRO. As electric and magnetic fields may interfere with the functional reliability of the device, avoid using g.Estim PRO close to devices emitting powerful magnetic fields, e.g. magnetic resonance machines or x-ray equipment.

11.1 GUIDANCE AND MANUFACTURER'S DECLARATION

**WARNING:**

Use of this equipment immediately adjacent to other equipment or with other equipment in a stacked configuration should be avoided as it may result in improper operation. If use in a setup described above is nevertheless necessary, this equipment and the other equipment should be observed to convince yourself that they operate properly.

**WARNING:**

The use of accessories, transducers, and wiring other than those specified or provided by the manufacturer of this equipment may result in increased electrical emissions or decreased electromagnetic immunity of the equipment and may result in incorrect operation.

**NOTE:**

All accessories and components listed in Section 5 do not negatively affect the electromagnetic compatibility. Follow instructions in Section 5 for any other connected accessories.

11.1.1 ELECTROMAGNETIC EMISSION

The g.Estim PRO is intended for use in the electromagnetic environment specified below. The customer or the user of the g.Estim PRO should assure that it is used in such an environment.

Emission test	Compliance	Electromagnetic Environment Guidance
RF emissions CISPR 11	Group 1	The g.Estim PRO uses RF energy only for its internal function. Therefore, its RF emissions are very low and are not likely to cause any interference in nearby electronic equipment.
HF- emissions CISPR 11	Class B	The g.Estim PRO is suitable for use in all establishments, including domestic establishments and those directly connected to the public low-voltage power supply network that supplies buildings used for domestic purposes.
Harmonic emissions IEC 61000-3-2	Not applicable	
Voltage fluctuations/flicker emissions IEC 61000-3-3	Not applicable	

11.1.2 ELECTROMAGNETIC IMMUNITY

The g.Estim PRO is intended for use in the electromagnetic environment specified below.



NOTE:

Electromagnetic disturbances may cause g.Estim PRO stopping stimulation if current monitoring identifies fluctuations. In such cases, the stimulation will not restart automatically. Assure that g.Estim PRO is used in the specified environment. Re-activation of g.Estim PRO is possible at any time if electromagnetic disturbances are below compliance level.

Immunity test	IEC 60601 test level	Compliance level	Electromagnetic environment - guidance
Electrostatic discharge (ESD) IEC 61000-4-2	± 8 kV contact ± 15 kV air	± 8 kV contact ± 15 kV air	Floors should be wood, concrete or ceramic tile. If floors are covered with synthetic material, the relative humidity should be at least 30 %.
Electrical fast transient/burst according to IEC 61000-4-4	± 2 kV for power supply lines ± 1 kV for input/output lines	+/- 1 kV for input/output lines	Mains power quality should be that of a typical commercial or hospital environment.
Surges according to IEC 61000-4-5	± 1 kV differential mode ± 2 kV common mode	Not applicable	Mains power quality should be that of a typical commercial or hospital environment.
Voltage dips, short interruptions and voltage variations on power supply input lines IEC 61000-4-11	< 5 % UT (> 95 % dip in UT) for ½ cycle 40 % UT (60 % dip in UT) for 5 cycles 70 % UT (30 % dip in UT) for 25 cycles < 5 % UT (> 95 % dip in UT) for 5 s	Not applicable	Mains power quality should be that of a typical commercial or hospital environment. If the use of the g.Estim PRO requires continued operation during power mains interrupts, it is recommended that the g.Estim PRO be powered from an uninterruptible power supply or a battery.
Power frequency (50 Hz/60 Hz) magnetic field IEC 61000-4-8	30 A/m	Not applicable	Power frequency magnetic fields should be at levels characteristic of a typical location in a typical commercial or hospital environment.



NOTE:

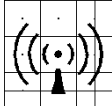
UT is the a.c. mains voltage prior to application of the test level.

Immunity test	IEC 60601 test level	Compliance level	Electromagnetic environment - guidance
conducted RF IEC 61000-4-6	3 V _{eff} 150 kHz to 80 MHz	3 V	
conducted RF IEC 61000-4-6 for ISM frequency bands	6 V _{eff} 150 kHz to 80 MHz	6 V	ISM frequency bands: 6,765 MHz to 6,795 MHz, 13,553 MHz to 13,567 MHz, 26,957 MHz to 27,283 MHz, 40,66 MHz to 40,70 MHz
Proximity fields from RF wireless communications equipment IEC 61000-4-3			Devices utilizing the following radio services should not be used closer than 30 cm distance to g.Estim PRO:
	9 V/m	9 V/m	704 to 787 MHz (LTE Band 13, 17)
			5100 to 5800 MHz (WLAN 802.11 a/n)
	27 V/m	27 V/m	380 to 390 MHz (TETRA 400)
	28 V/m	28 V/m	430 to 470 MHz (GMRS 460, FRS 460)
			800 to 960 MHz (GSM 800/900, TETRA 800, iDEN 820, CDMA 850, LTE Band 5) 1700 to 1990 MHz (GSM 1800, CDMA 1900, GSM 1900, DECT, LTE Band 1, 3, 4, 25, UMTS)
			2400 to 2570 MHz (Bluetooth, WLAN 802.11 b/g/n, RFID 2450, LTE Band 7)



WARNING:

Portable RF communications equipment (radios) (including their accessories such as antenna cables and external antennas) should not be used within 30 cm (or 12 inches) of the g.Estim PRO's parts and leads. Failure to do so may result in a reduction in the performance characteristics of the device.

Immunity test	IEC 60601 test level	Compliance level	Electromagnetic environment - guidance
Radiated RF IEC 61000-4-3	3 V/m 80 MHz to 2,7 GHz	3 → E in V/m	<p>Portable and mobile RF communications equipment, which utilizes other than the aforementioned radio services, should be used no closer to any part of the g.Estim PRO, including cables, than the recommended separation distance calculated from the equation:</p> <p>Recommended separation distance $E = \left(\frac{6}{d}\right) * \sqrt{P} \text{ or } d = \left(\frac{6}{E}\right) * \sqrt{P}$ </p> <p>Where P is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer and d is the separation distance in meters (m).^b</p> <p>Field strengths from fixed RF transmitters, as determined by an electromagnetic site survey,^a should be less than the compliance level.^b</p> <p>Interference may occur in the vicinity of equipment marked with the following symbol:</p> 

^a Field strengths from fixed transmitters, such as base stations for radio (cellular /cordless) telephones and land mobile radios, amateur radio, AM and FM radio broadcast and TV broadcast cannot be predicted theoretically with accuracy. To assess the electromagnetic environment due to fixed RF transmitters, an electromagnetic site survey should be considered. If the measured field strength in the location in which the g.Estim PRO is used exceeds the applicable RF compliance level above, the g.Estim PRO should be observed to verify normal operation. If abnormal performance is observed, additional measures may be necessary, such as reorienting or relocating the g.Estim PRO.

^b Over the frequency range 80 MHz to 2.7 GHz, field strengths should be less than 3 V/m.



NOTE:

These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.

The customer or the user of the g.Estim PRO can help prevent electromagnetic interference by maintaining a minimum distance between portable and mobile RF communications equipment (transmitters) and the g.Estim PRO as recommended below, according to the maximum output power of the communications equipment.

Rated maximum output power of RF transmitter (W)	Separation distance (m)
P	$d = \left(\frac{6}{E}\right) * \sqrt{P}$
0,01	0,20
0,1	0,63
1	2,00
10	6,32
100	20,00

For transmitters rated at a maximum output power not listed above, the recommended separation distance d in metres (m) can be determined using the equation applicable to the frequency of the RF transmitter, where P is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer.

12 APPENDICES

Appendix A: Output voltage dependency from stimulation current and load

According to Ohm's law (1) the stimulation output voltage $U_{\text{Stimulation}}$ is directly proportional to the settled stimulation current $I_{\text{Stimulation}}$ and load resistance R_{load} . This dependency is also shown in Figure 1.

$$U_{\text{Stimulation}} = I_{\text{Stimulation}} \times R_{\text{load}} \quad (1)$$

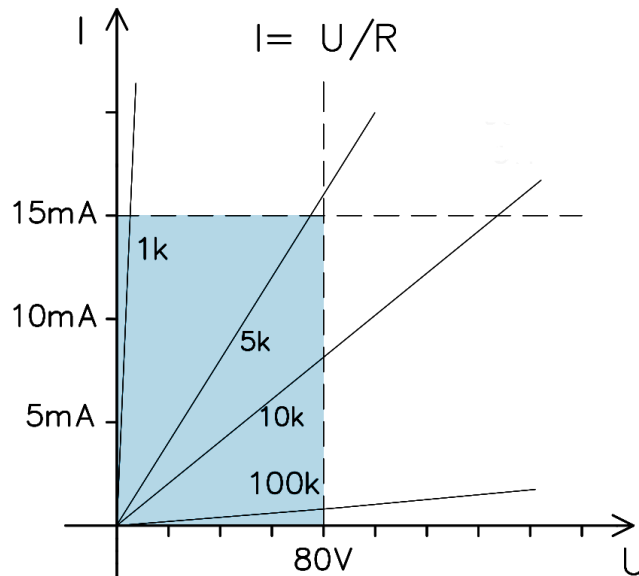


Figure 1: Current/voltage/resistance dependency with respect to g.Estim PRO limits. Stimulation is possible with values within the blue area.

Appendix B: Rise and fall time dependency from load

B.1 Definitions

Figure 2 shows a single stimulation current phase with the rise and fall time. Rise and fall time are part of a single phase duration.

B.2 Expected signal amplitude

The amplitude equal to 100% of the settled phase current amplitude.

B.3 Rise time

The time taken by the stimulation signal to change from 10% to 90% of the expected signal amplitude.

B.4 Fall time

The time taken by the stimulation signal to change from 90% to 10% of the expected signal amplitude.

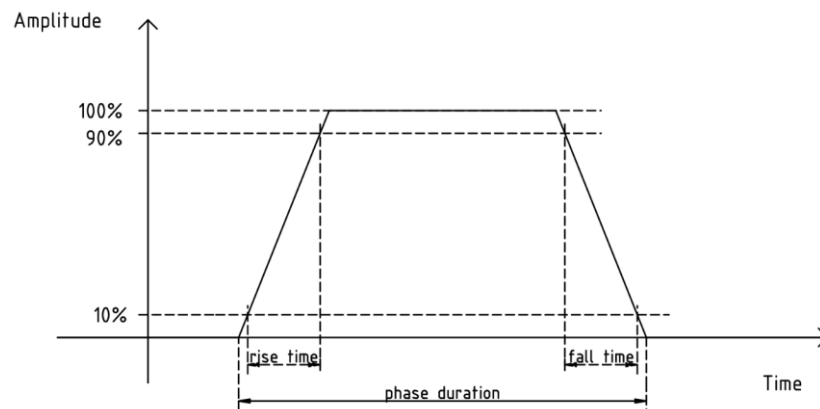


Figure 2: Rise/Fall time definition

B.5 Dependency

Rise time (t_r) and fall time (t_f) dependency from load resistance R_{load} :

$$\forall 5k\Omega \leq R_{load} \leq 800k\Omega: t_r = t_f < (R_{load} \times 1ns)$$

$$\forall R_{load} < 5k\Omega: t_r = t_f < 5\mu s$$

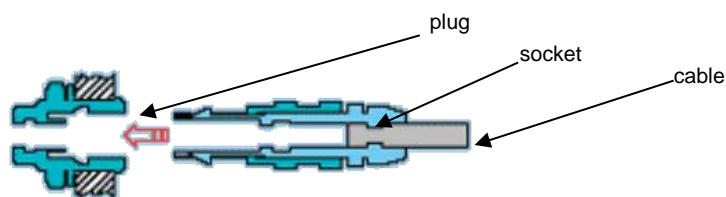
$$\text{e.g. } R_{load} = 60k\Omega: \rightarrow t_r = t_f < 60\mu s$$

R_{load}	$t_r = t_f$
10 k Ω	< 10 μs
50 k Ω	< 50 μs
100 k Ω	< 100 μs
500 k Ω	< 500 μs
800 k Ω	< 800 μs

Appendix C: Push-Pull Connectors

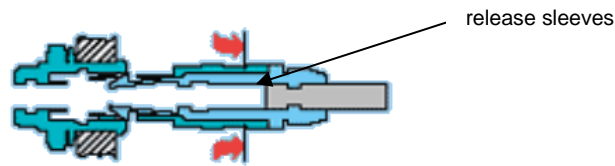
g.Estim PRO connections on the rear side and for the hand/foot-switch rely on highly reliable self-latching connectors based on the push-pull principle.

C.1 Connecting a plug to the corresponding socket



For connecting the self-latching plug to the socket push the plug axially into the socket.

C.2 Disconnecting a plug from a socket



For disconnecting the plug from the socket pull on the outer release sleeves only.



NOTE:

It is not necessary to use any tool to disconnect the plug from the socket.



NOTE:

Connecting or disconnecting cables to/from the g.Estim PRO must be done when the device is switched off, by grasping cable connectors (do not pull on wires). The person who performs wiring must not be in physical contact with the patient.

Appendix D: Charge density tables

The tables on the following pages list the applied charge densities per phase for electrodes with different exposed surface in $\mu\text{C}/\text{cm}^2$ depending on the phase duration in ms and the stimulation amplitude in mA. They can be used as reference for looking up harmless stimulation settings depending on the electrodes that are used. Additionally the g.Estim PRO control software shows the information presented in those tables and checks for safe stimulation if the user has entered the exposed electrode area of the used electrodes.

Example calculation:

For calculating the applied charge density of a stimulation using surface electrodes with an exposed diameter of 2.3 mm and a pulse train containing phases with 3 mA current amplitude and 1 ms phase width the following steps are taken: First the exposed stimulation area of the electrode is calculated according (in this case) to the formula for the area of a circle

$$A = \pi r^2$$

where r is the radius of the exposed area in mm (i.e. the exposed diameter divided by 2) and A is the resulting exposed stimulation area in mm^2 . Therefore, the exposed stimulation area of the electrode is 4.155 mm^2 .

The applied charge per phase Q_{phase} in μC is calculated according to

$$Q_{\text{phase}} = I * t$$

where t is the phase width in ms, and I is the stimulation pulse amplitude in mA. Therefore, the phase charge is $3 \mu\text{C}$.

With these results it is now possible to calculate the charge density according to

$$CD = \frac{Q_{phase}}{A} * 100$$

The charge density CD is 72.2 $\mu\text{C}/\text{cm}^2$.



WARNING:

A charge density per phase of less than 50 $\mu\text{C}/\text{cm}^2$ is considered as safe. A charge density per phase above 50 $\mu\text{C}/\text{cm}^2$ and below 150 $\mu\text{C}/\text{cm}^2$ has a potential risk to cause damage to the stimulated tissue. A charge density per phase above 150 $\mu\text{C}/\text{cm}^2$ can damage the stimulated tissue.

D. B. McCreery, W. F. Agnew, T. G. Yuen, and L. Bullara, "Charge density and charge per phase as cofactors in neural injury induced by electrical stimulation," IEEE Trans Biomed Eng, vol. 37, no. 10, pp. 996–1001, Oct. 1990.

Table legend:

$0 \leq x < 50 \mu\text{C}/\text{cm}^2$	$50 \leq x < 150 \mu\text{C}/\text{cm}^2$	$150 \leq x < 375 \mu\text{C}/\text{cm}^2$	$x > 375 \mu\text{C}/\text{cm}^2$
Safe stimulation possible	Potential risk of tissue damage	Stimulation can damage tissue	Danger! Not allowed by software

Charge densities ($\mu\text{C}/\text{cm}^2$) for exposed stimulation areas from 1.5 to 20 mm^2 , stimulation current amplitudes from 1 to 15 mA and a phase length of 100 μs .

Exposed stimulation area (mm^2)	Current amplitude (mA)														
	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0
1.50	6.7	13.3	20.0	26.7	33.3	40.0	46.7	53.3	60.0	66.7	73.3	80.0	86.7	93.3	100.0
1.75	5.7	11.4	17.1	22.9	28.6	34.3	40.0	45.7	51.4	57.1	62.9	68.6	74.3	80.0	85.7
2.00	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0	65.0	70.0	75.0
2.25	4.4	8.9	13.3	17.8	22.2	26.7	31.1	35.6	40.0	44.4	48.9	53.3	57.8	62.2	66.7
2.50	4.0	8.0	12.0	16.0	20.0	24.0	28.0	32.0	36.0	40.0	44.0	48.0	52.0	56.0	60.0
2.75	3.6	7.3	10.9	14.5	18.2	21.8	25.5	29.1	32.7	36.4	40.0	43.6	47.3	50.9	54.5
3.00	3.3	6.7	10.0	13.3	16.7	20.0	23.3	26.7	30.0	33.3	36.7	40.0	43.3	46.7	50.0
3.25	3.1	6.2	9.2	12.3	15.4	18.5	21.5	24.6	27.7	30.8	33.8	36.9	40.0	43.1	46.2
3.50	2.9	5.7	8.6	11.4	14.3	17.1	20.0	22.9	25.7	28.6	31.4	34.3	37.1	40.0	42.9
3.75	2.7	5.3	8.0	10.7	13.3	16.0	18.7	21.3	24.0	26.7	29.3	32.0	34.7	37.3	40.0
4.00	2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0	27.5	30.0	32.5	35.0	37.5
4.25	2.4	4.7	7.1	9.4	11.8	14.1	16.5	18.8	21.2	23.5	25.9	28.2	30.6	32.9	35.3
4.50	2.2	4.4	6.7	8.9	11.1	13.3	15.6	17.8	20.0	22.2	24.4	26.7	28.9	31.1	33.3
4.75	2.1	4.2	6.3	8.4	10.5	12.6	14.7	16.8	18.9	21.1	23.2	25.3	27.4	29.5	31.6
5.00	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0	26.0	28.0	30.0
5.25	1.9	3.8	5.7	7.6	9.5	11.4	13.3	15.2	17.1	19.0	21.0	22.9	24.8	26.7	28.6
5.50	1.8	3.6	5.5	7.3	9.1	10.9	12.7	14.5	16.4	18.2	20.0	21.8	23.6	25.5	27.3
5.75	1.7	3.5	5.2	7.0	8.7	10.4	12.2	13.9	15.7	17.4	19.1	20.9	22.6	24.3	26.1
6.00	1.7	3.3	5.0	6.7	8.3	10.0	11.7	13.3	15.0	16.7	18.3	20.0	21.7	23.3	25.0
6.25	1.6	3.2	4.8	6.4	8.0	9.6	11.2	12.8	14.4	16.0	17.6	19.2	20.8	22.4	24.0
6.50	1.5	3.1	4.6	6.2	7.7	9.2	10.8	12.3	13.8	15.4	16.9	18.5	20.0	21.5	23.1
6.75	1.5	3.0	4.4	5.9	7.4	8.9	10.4	11.9	13.3	14.8	16.3	17.8	19.3	20.7	22.2
7.00	1.4	2.9	4.3	5.7	7.1	8.6	10.0	11.4	12.9	14.3	15.7	17.1	18.6	20.0	21.4
7.25	1.4	2.8	4.1	5.5	6.9	8.3	9.7	11.0	12.4	13.8	15.2	16.6	17.9	19.3	20.7
7.50	1.3	2.7	4.0	5.3	6.7	8.0	9.3	10.7	12.0	13.3	14.7	16.0	17.3	18.7	20.0
7.75	1.3	2.6	3.9	5.2	6.5	7.7	9.0	10.3	11.6	12.9	14.2	15.5	16.8	18.1	19.4
8.00	1.3	2.5	3.8	5.0	6.3	7.5	8.8	10.0	11.3	12.5	13.8	15.0	16.3	17.5	18.8
8.25	1.2	2.4	3.6	4.8	6.1	7.3	8.5	9.7	10.9	12.1	13.3	14.5	15.8	17.0	18.2
8.50	1.2	2.4	3.5	4.7	5.9	7.1	8.2	9.4	10.6	11.8	12.9	14.1	15.3	16.5	17.6
8.75	1.1	2.3	3.4	4.6	5.7	6.9	8.0	9.1	10.3	11.4	12.6	13.7	14.9	16.0	17.1
9.00	1.1	2.2	3.3	4.4	5.6	6.7	7.8	8.9	10.0	11.1	12.2	13.3	14.4	15.6	16.7
9.25	1.1	2.2	3.2	4.3	5.4	6.5	7.6	8.6	9.7	10.8	11.9	13.0	14.1	15.1	16.2
9.50	1.1	2.1	3.2	4.2	5.3	6.3	7.4	8.4	9.5	10.5	11.6	12.6	13.7	14.7	15.8
9.75	1.0	2.1	3.1	4.1	5.1	6.2	7.2	8.2	9.2	10.3	11.3	12.3	13.3	14.4	15.4
10.00	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0
10.50	1.0	1.9	2.9	3.8	4.8	5.7	6.7	7.6	8.6	9.5	10.5	11.4	12.4	13.3	14.3
11.00	0.9	1.8	2.7	3.6	4.5	5.5	6.4	7.3	8.2	9.1	10.0	10.9	11.8	12.7	13.6
11.50	0.9	1.7	2.6	3.5	4.3	5.2	6.1	7.0	7.8	8.7	9.6	10.4	11.3	12.2	13.0
12.00	0.8	1.7	2.5	3.3	4.2	5.0	5.8	6.7	7.5	8.3	9.2	10.0	10.8	11.7	12.5
12.50	0.8	1.6	2.4	3.2	4.0	4.8	5.6	6.4	7.2	8.0	8.8	9.6	10.4	11.2	12.0
13.00	0.8	1.5	2.3	3.1	3.8	4.6	5.4	6.2	6.9	7.7	8.5	9.2	10.0	10.8	11.5
13.50	0.7	1.5	2.2	3.0	3.7	4.4	5.2	5.9	6.7	7.4	8.1	8.9	9.6	10.4	11.1
14.00	0.7	1.4	2.1	2.9	3.6	4.3	5.0	5.7	6.4	7.1	7.9	8.6	9.3	10.0	10.7
14.50	0.7	1.4	2.1	2.8	3.4	4.1	4.8	5.5	6.2	6.9	7.6	8.3	9.0	9.7	10.3
15.00	0.7	1.3	2.0	2.7	3.3	4.0	4.7	5.3	6.0	6.7	7.3	8.0	8.7	9.3	10.0
15.50	0.6	1.3	1.9	2.6	3.2	3.9	4.5	5.2	5.8	6.5	7.1	7.7	8.4	9.0	9.7
16.00	0.6	1.3	1.9	2.5	3.1	3.8	4.4	5.0	5.6	6.3	6.9	7.5	8.1	8.8	9.4
16.50	0.6	1.2	1.8	2.4	3.0	3.6	4.2	4.8	5.5	6.1	6.7	7.3	7.9	8.5	9.1
17.00	0.6	1.2	1.8	2.4	2.9	3.5	4.1	4.7	5.3	5.9	6.5	7.1	7.6	8.2	8.8
17.50	0.6	1.1	1.7	2.3	2.9	3.4	4.0	4.6	5.1	5.7	6.3	6.9	7.4	8.0	8.6
18.00	0.6	1.1	1.7	2.2	2.8	3.3	3.9	4.4	5.0	5.6	6.1	6.7	7.2	7.8	8.3
18.50	0.5	1.1	1.6	2.2	2.7	3.2	3.8	4.3	4.9	5.4	5.9	6.5	7.0	7.6	8.1
19.00	0.5	1.1	1.6	2.1	2.6	3.2	3.7	4.2	4.7	5.3	5.8	6.3	6.8	7.4	7.9
19.50	0.5	1.0	1.5	2.1	2.6	3.1	3.6	4.1	4.6	5.1	5.6	6.2	6.7	7.2	7.7
20.00	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5

Charge densities ($\mu\text{C}/\text{cm}^2$) for exposed stimulation areas from 1.5 to 20 mm^2 , stimulation current amplitudes from 1 to 15 mA and a phase length of 200 μs .

Exposed stimulation area (mm²)	Current amplitude (mA)														
	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0
1.50	13.3	26.7	40.0	53.3	66.7	80.0	93.3	106.7	120.0	133.3	146.7	160.0	173.3	186.7	200.0
1.75	11.4	22.9	34.3	45.7	57.1	68.6	80.0	91.4	102.9	114.3	125.7	137.1	148.6	160.0	171.4
2.00	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	110.0	120.0	130.0	140.0	150.0
2.25	8.9	17.8	26.7	35.6	44.4	53.3	62.2	71.1	80.0	88.9	97.8	106.7	115.6	124.4	133.3
2.50	8.0	16.0	24.0	32.0	40.0	48.0	56.0	64.0	72.0	80.0	88.0	96.0	104.0	112.0	120.0
2.75	7.3	14.5	21.8	29.1	36.4	43.6	50.9	58.2	65.5	72.7	80.0	87.3	94.5	101.8	109.1
3.00	6.7	13.3	20.0	26.7	33.3	40.0	46.7	53.3	60.0	66.7	73.3	80.0	86.7	93.3	100.0
3.25	6.2	12.3	18.5	24.6	30.8	36.9	43.1	49.2	55.4	61.5	67.7	73.8	80.0	86.2	92.3
3.50	5.7	11.4	17.1	22.9	28.6	34.3	40.0	45.7	51.4	57.1	62.9	68.6	74.3	80.0	85.7
3.75	5.3	10.7	16.0	21.3	26.7	32.0	37.3	42.7	48.0	53.3	58.7	64.0	69.3	74.7	80.0
4.00	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0	65.0	70.0	75.0
4.25	4.7	9.4	14.1	18.8	23.5	28.2	32.9	37.6	42.4	47.1	51.8	56.5	61.2	65.9	70.6
4.50	4.4	8.9	13.3	17.8	22.2	26.7	31.1	35.6	40.0	44.4	48.9	53.3	57.8	62.2	66.7
4.75	4.2	8.4	12.6	16.8	21.1	25.3	29.5	33.7	37.9	42.1	46.3	50.5	54.7	58.9	63.2
5.00	4.0	8.0	12.0	16.0	20.0	24.0	28.0	32.0	36.0	40.0	44.0	48.0	52.0	56.0	60.0
5.25	3.8	7.6	11.4	15.2	19.0	22.9	26.7	30.5	34.3	38.1	41.9	45.7	49.5	53.3	57.1
5.50	3.6	7.3	10.9	14.5	18.2	21.8	25.5	29.1	32.7	36.4	40.0	43.6	47.3	50.9	54.5
5.75	3.5	7.0	10.4	13.9	17.4	20.9	24.3	27.8	31.3	34.8	38.3	41.7	45.2	48.7	52.2
6.00	3.3	6.7	10.0	13.3	16.7	20.0	23.3	26.7	30.0	33.3	36.7	40.0	43.3	46.7	50.0
6.25	3.2	6.4	9.6	12.8	16.0	19.2	22.4	25.6	28.8	32.0	35.2	38.4	41.6	44.8	48.0
6.50	3.1	6.2	9.2	12.3	15.4	18.5	21.5	24.6	27.7	30.8	33.8	36.9	40.0	43.1	46.2
6.75	3.0	5.9	8.9	11.9	14.8	17.8	20.7	23.7	26.7	29.6	32.6	35.6	38.5	41.5	44.4
7.00	2.9	5.7	8.6	11.4	14.3	17.1	20.0	22.9	25.7	28.6	31.4	34.3	37.1	40.0	42.9
7.25	2.8	5.5	8.3	11.0	13.8	16.6	19.3	22.1	24.8	27.6	30.3	33.1	35.9	38.6	41.4
7.50	2.7	5.3	8.0	10.7	13.3	16.0	18.7	21.3	24.0	26.7	29.3	32.0	34.7	37.3	40.0
7.75	2.6	5.2	7.7	10.3	12.9	15.5	18.1	20.6	23.2	25.8	28.4	31.0	33.5	36.1	38.7
8.00	2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0	27.5	30.0	32.5	35.0	37.5
8.25	2.4	4.8	7.3	9.7	12.1	14.5	17.0	19.4	21.8	24.2	26.7	29.1	31.5	33.9	36.4
8.50	2.4	4.7	7.1	9.4	11.8	14.1	16.5	18.8	21.2	23.5	25.9	28.2	30.6	32.9	35.3
8.75	2.3	4.6	6.9	9.1	11.4	13.7	16.0	18.3	20.6	22.9	25.1	27.4	29.7	32.0	34.3
9.00	2.2	4.4	6.7	8.9	11.1	13.3	15.6	17.8	20.0	22.2	24.4	26.7	28.9	31.1	33.3
9.25	2.2	4.3	6.5	8.6	10.8	13.0	15.1	17.3	19.5	21.6	23.8	25.9	28.1	30.3	32.4
9.50	2.1	4.2	6.3	8.4	10.5	12.6	14.7	16.8	18.9	21.1	23.2	25.3	27.4	29.5	31.6
9.75	2.1	4.1	6.2	8.2	10.3	12.3	14.4	16.4	18.5	20.5	22.6	24.6	26.7	28.7	30.8
10.00	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0	26.0	28.0	30.0
10.50	1.9	3.8	5.7	7.6	9.5	11.4	13.3	15.2	17.1	19.0	21.0	22.9	24.8	26.7	28.6
11.00	1.8	3.6	5.5	7.3	9.1	10.9	12.7	14.5	16.4	18.2	20.0	21.8	23.6	25.5	27.3
11.50	1.7	3.5	5.2	7.0	8.7	10.4	12.2	13.9	15.7	17.4	19.1	20.9	22.6	24.3	26.1
12.00	1.7	3.3	5.0	6.7	8.3	10.0	11.7	13.3	15.0	16.7	18.3	20.0	21.7	23.3	25.0
12.50	1.6	3.2	4.8	6.4	8.0	9.6	11.2	12.8	14.4	16.0	17.6	19.2	20.8	22.4	24.0
13.00	1.5	3.1	4.6	6.2	7.7	9.2	10.8	12.3	13.8	15.4	16.9	18.5	20.0	21.5	23.1
13.50	1.5	3.0	4.4	5.9	7.4	8.9	10.4	11.9	13.3	14.8	16.3	17.8	19.3	20.7	22.2
14.00	1.4	2.9	4.3	5.7	7.1	8.6	10.0	11.4	12.9	14.3	15.7	17.1	18.6	20.0	21.4
14.50	1.4	2.8	4.1	5.5	6.9	8.3	9.7	11.0	12.4	13.8	15.2	16.6	17.9	19.3	20.7
15.00	1.3	2.7	4.0	5.3	6.7	8.0	9.3	10.7	12.0	13.3	14.7	16.0	17.3	18.7	20.0
15.50	1.3	2.6	3.9	5.2	6.5	7.7	9.0	10.3	11.6	12.9	14.2	15.5	16.8	18.1	19.4
16.00	1.3	2.5	3.8	5.0	6.3	7.5	8.8	10.0	11.3	12.5	13.8	15.0	16.3	17.5	18.8
16.50	1.2	2.4	3.6	4.8	6.1	7.3	8.5	9.7	10.9	12.1	13.3	14.5	15.8	17.0	18.2
17.00	1.2	2.4	3.5	4.7	5.9	7.1	8.2	9.4	10.6	11.8	12.9	14.1	15.3	16.5	17.6
17.50	1.1	2.3	3.4	4.6	5.7	6.9	8.0	9.1	10.3	11.4	12.6	13.7	14.9	16.0	17.1
18.00	1.1	2.2	3.3	4.4	5.6	6.7	7.8	8.9	10.0	11.1	12.2	13.3	14.4	15.6	16.7
18.50	1.1	2.2	3.2	4.3	5.4	6.5	7.6	8.6	9.7	10.8	11.9	13.0	14.1	15.1	16.2
19.00	1.1	2.1	3.2	4.2	5.3	6.3	7.4	8.4	9.5	10.5	11.6	12.6	13.7	14.7	15.8
19.50	1.0	2.1	3.1	4.1	5.1	6.2	7.2	8.2	9.2	10.3	11.3	12.3	13.3	14.4	15.4
20.00	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0

Charge densities ($\mu\text{C}/\text{cm}^2$) for exposed stimulation areas from 1.5 to 20 mm^2 , stimulation current amplitudes from 1 to 15 mA and a phase length of 300 μs .

Exposed stimulation area (mm^2)	Current amplitude (mA)														
	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0
1.50	20.0	40.0	60.0	80.0	100.0	120.0	140.0	160.0	180.0	200.0	220.0	240.0	260.0	280.0	300.0
1.75	17.1	34.3	51.4	68.6	85.7	102.9	120.0	137.1	154.3	171.4	188.6	205.7	222.9	240.0	257.1
2.00	15.0	30.0	45.0	60.0	75.0	90.0	105.0	120.0	135.0	150.0	165.0	180.0	195.0	210.0	225.0
2.25	13.3	26.7	40.0	53.3	66.7	80.0	93.3	106.7	120.0	133.3	146.7	160.0	173.3	186.7	200.0
2.50	12.0	24.0	36.0	48.0	60.0	72.0	84.0	96.0	108.0	120.0	132.0	144.0	156.0	168.0	180.0
2.75	10.9	21.8	32.7	43.6	54.5	65.5	76.4	87.3	98.2	109.1	120.0	130.9	141.8	152.7	163.6
3.00	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	110.0	120.0	130.0	140.0	150.0
3.25	9.2	18.5	27.7	36.9	46.2	55.4	64.6	73.8	83.1	92.3	101.5	110.8	120.0	129.2	138.5
3.50	8.6	17.1	25.7	34.3	42.9	51.4	60.0	68.6	77.1	85.7	94.3	102.9	111.4	120.0	128.6
3.75	8.0	16.0	24.0	32.0	40.0	48.0	56.0	64.0	72.0	80.0	88.0	96.0	104.0	112.0	120.0
4.00	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	97.5	105.0	112.5
4.25	7.1	14.1	21.2	28.2	35.3	42.4	49.4	56.5	63.5	70.6	77.6	84.7	91.8	98.8	105.9
4.50	6.7	13.3	20.0	26.7	33.3	40.0	46.7	53.3	60.0	66.7	73.3	80.0	86.7	93.3	100.0
4.75	6.3	12.6	18.9	25.3	31.6	37.9	44.2	50.5	56.8	63.2	69.5	75.8	82.1	88.4	94.7
5.00	6.0	12.0	18.0	24.0	30.0	36.0	42.0	48.0	54.0	60.0	66.0	72.0	78.0	84.0	90.0
5.25	5.7	11.4	17.1	22.9	28.6	34.3	40.0	45.7	51.4	57.1	62.9	68.6	74.3	80.0	85.7
5.50	5.5	10.9	16.4	21.8	27.3	32.7	38.2	43.6	49.1	54.5	60.0	65.5	70.9	76.4	81.8
5.75	5.2	10.4	15.7	20.9	26.1	31.3	36.5	41.7	47.0	52.2	57.4	62.6	67.8	73.0	78.3
6.00	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0	65.0	70.0	75.0
6.25	4.8	9.6	14.4	19.2	24.0	28.8	33.6	38.4	43.2	48.0	52.8	57.6	62.4	67.2	72.0
6.50	4.6	9.2	13.8	18.5	23.1	27.7	32.3	36.9	41.5	46.2	50.8	55.4	60.0	64.6	69.2
6.75	4.4	8.9	13.3	17.8	22.2	26.7	31.1	35.6	40.0	44.4	48.9	53.3	57.8	62.2	66.7
7.00	4.3	8.6	12.9	17.1	21.4	25.7	30.0	34.3	38.6	42.9	47.1	51.4	55.7	60.0	64.3
7.25	4.1	8.3	12.4	16.6	20.7	24.8	29.0	33.1	37.2	41.4	45.5	49.7	53.8	57.9	62.1
7.50	4.0	8.0	12.0	16.0	20.0	24.0	28.0	32.0	36.0	40.0	44.0	48.0	52.0	56.0	60.0
7.75	3.9	7.7	11.6	15.5	19.4	23.2	27.1	31.0	34.8	38.7	42.6	46.5	50.3	54.2	58.1
8.00	3.8	7.5	11.3	15.0	18.8	22.5	26.3	30.0	33.8	37.5	41.3	45.0	48.8	52.5	56.3
8.25	3.6	7.3	10.9	14.5	18.2	21.8	25.5	29.1	32.7	36.4	40.0	43.6	47.3	50.9	54.5
8.50	3.5	7.1	10.6	14.1	17.6	21.2	24.7	28.2	31.8	35.3	38.8	42.4	45.9	49.4	52.9
8.75	3.4	6.9	10.3	13.7	17.1	20.6	24.0	27.4	30.9	34.3	37.7	41.1	44.6	48.0	51.4
9.00	3.3	6.7	10.0	13.3	16.7	20.0	23.3	26.7	30.0	33.3	36.7	40.0	43.3	46.7	50.0
9.25	3.2	6.5	9.7	13.0	16.2	19.5	22.7	25.9	29.2	32.4	35.7	38.9	42.2	45.4	48.6
9.50	3.2	6.3	9.5	12.6	15.8	18.9	22.1	25.3	28.4	31.6	34.7	37.9	41.1	44.2	47.4
9.75	3.1	6.2	9.2	12.3	15.4	18.5	21.5	24.6	27.7	30.8	33.8	36.9	40.0	43.1	46.2
10.00	3.0	6.0	9.0	12.0	15.0	18.0	21.0	24.0	27.0	30.0	33.0	36.0	39.0	42.0	45.0
10.50	2.9	5.7	8.6	11.4	14.3	17.1	20.0	22.9	25.7	28.6	31.4	34.3	37.1	40.0	42.9
11.00	2.7	5.5	8.2	10.9	13.6	16.4	19.1	21.8	24.5	27.3	30.0	32.7	35.5	38.2	40.9
11.50	2.6	5.2	7.8	10.4	13.0	15.7	18.3	20.9	23.5	26.1	28.7	31.3	33.9	36.5	39.1
12.00	2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0	27.5	30.0	32.5	35.0	37.5
12.50	2.4	4.8	7.2	9.6	12.0	14.4	16.8	19.2	21.6	24.0	26.4	28.8	31.2	33.6	36.0
13.00	2.3	4.6	6.9	9.2	11.5	13.8	16.2	18.5	20.8	23.1	25.4	27.7	30.0	32.3	34.6
13.50	2.2	4.4	6.7	8.9	11.1	13.3	15.6	17.8	20.0	22.2	24.4	26.7	28.9	31.1	33.3
14.00	2.1	4.3	6.4	8.6	10.7	12.9	15.0	17.1	19.3	21.4	23.6	25.7	27.9	30.0	32.1
14.50	2.1	4.1	6.2	8.3	10.3	12.4	14.5	16.6	18.6	20.7	22.8	24.8	26.9	29.0	31.0
15.00	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0	26.0	28.0	30.0
15.50	1.9	3.9	5.8	7.7	9.7	11.6	13.5	15.5	17.4	19.4	21.3	23.2	25.2	27.1	29.0
16.00	1.9	3.8	5.6	7.5	9.4	11.3	13.1	15.0	16.9	18.8	20.6	22.5	24.4	26.3	28.1
16.50	1.8	3.6	5.5	7.3	9.1	10.9	12.7	14.5	16.4	18.2	20.0	21.8	23.6	25.5	27.3
17.00	1.8	3.5	5.3	7.1	8.8	10.6	12.4	14.1	15.9	17.6	19.4	21.2	22.9	24.7	26.5
17.50	1.7	3.4	5.1	6.9	8.6	10.3	12.0	13.7	15.4	17.1	18.9	20.6	22.3	24.0	25.7
18.00	1.7	3.3	5.0	6.7	8.3	10.0	11.7	13.3	15.0	16.7	18.3	20.0	21.7	23.3	25.0
18.50	1.6	3.2	4.9	6.5	8.1	9.7	11.4	13.0	14.6	16.2	17.8	19.5	21.1	22.7	24.3
19.00	1.6	3.2	4.7	6.3	7.9	9.5	11.1	12.6	14.2	15.8	17.4	18.9	20.5	22.1	23.7
19.50	1.5	3.1	4.6	6.2	7.7	9.2	10.8	12.3	13.8	15.4	16.9	18.5	20.0	21.5	23.1
20.00	1.5	3.0	4.5	6.0	7.5	9.0	10.5	12.0	13.5	15.0	16.5	18.0	19.5	21.0	22.5

Charge densities ($\mu\text{C}/\text{cm}^2$) for exposed stimulation areas from 1.5 to 20 mm^2 , stimulation current amplitudes from 1 to 15 mA and a phase length of 400 μs .

Exposed stimulation area (mm^2)	Current amplitude (mA)														
	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0
1.50	26.7	53.3	80.0	106.7	133.3	160.0	186.7	213.3	240.0	266.7	293.3	320.0	346.7	373.3	400.0
1.75	22.9	45.7	68.6	91.4	114.3	137.1	160.0	182.9	205.7	228.6	251.4	274.3	297.1	320.0	342.9
2.00	20.0	40.0	60.0	80.0	100.0	120.0	140.0	160.0	180.0	200.0	220.0	240.0	260.0	280.0	300.0
2.25	17.8	35.6	53.3	71.1	88.9	106.7	124.4	142.2	160.0	177.8	195.6	213.3	231.1	248.9	266.7
2.50	16.0	32.0	48.0	64.0	80.0	96.0	112.0	128.0	144.0	160.0	176.0	192.0	208.0	224.0	240.0
2.75	14.5	29.1	43.6	58.2	72.7	87.3	101.8	116.4	130.9	145.5	160.0	174.5	189.1	203.6	218.2
3.00	13.3	26.7	40.0	53.3	66.7	80.0	93.3	106.7	120.0	133.3	146.7	160.0	173.3	186.7	200.0
3.25	12.3	24.6	36.9	49.2	61.5	73.8	86.2	98.5	110.8	123.1	135.4	147.7	160.0	172.3	184.6
3.50	11.4	22.9	34.3	45.7	57.1	68.6	80.0	91.4	102.9	114.3	125.7	137.1	148.6	160.0	171.4
3.75	10.7	21.3	32.0	42.7	53.3	64.0	74.7	85.3	96.0	106.7	117.3	128.0	138.7	149.3	160.0
4.00	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	110.0	120.0	130.0	140.0	150.0
4.25	9.4	18.8	28.2	37.6	47.1	56.5	65.9	75.3	84.7	94.1	103.5	112.9	122.4	131.8	141.2
4.50	8.9	17.8	26.7	35.6	44.4	53.3	62.2	71.1	80.0	88.9	97.8	106.7	115.6	124.4	133.3
4.75	8.4	16.8	25.3	33.7	42.1	50.5	58.9	67.4	75.8	84.2	92.6	101.1	109.5	117.9	126.3
5.00	8.0	16.0	24.0	32.0	40.0	48.0	56.0	64.0	72.0	80.0	88.0	96.0	104.0	112.0	120.0
5.25	7.6	15.2	22.9	30.5	38.1	45.7	53.3	61.0	68.6	76.2	83.8	91.4	99.0	106.7	114.3
5.50	7.3	14.5	21.8	29.1	36.4	43.6	50.9	58.2	65.5	72.7	80.0	87.3	94.5	101.8	109.1
5.75	7.0	13.9	20.9	27.8	34.8	41.7	48.7	55.7	62.6	69.6	76.5	83.5	90.4	97.4	104.3
6.00	6.7	13.3	20.0	26.7	33.3	40.0	46.7	53.3	60.0	66.7	73.3	80.0	86.7	93.3	100.0
6.25	6.4	12.8	19.2	25.6	32.0	38.4	44.8	51.2	57.6	64.0	70.4	76.8	83.2	89.6	96.0
6.50	6.2	12.3	18.5	24.6	30.8	36.9	43.1	49.2	55.4	61.5	67.7	73.8	80.0	86.2	92.3
6.75	5.9	11.9	17.8	23.7	29.6	35.6	41.5	47.4	53.3	59.3	65.2	71.1	77.0	83.0	88.9
7.00	5.7	11.4	17.1	22.9	28.6	34.3	40.0	45.7	51.4	57.1	62.9	68.6	74.3	80.0	85.7
7.25	5.5	11.0	16.6	22.1	27.6	33.1	38.6	44.1	49.7	55.2	60.7	66.2	71.7	77.2	82.8
7.50	5.3	10.7	16.0	21.3	26.7	32.0	37.3	42.7	48.0	53.3	58.7	64.0	69.3	74.7	80.0
7.75	5.2	10.3	15.5	20.6	25.8	31.0	36.1	41.3	46.5	51.6	56.8	61.9	67.1	72.3	77.4
8.00	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0	65.0	70.0	75.0
8.25	4.8	9.7	14.5	19.4	24.2	29.1	33.9	38.8	43.6	48.5	53.3	58.2	63.0	67.9	72.7
8.50	4.7	9.4	14.1	18.8	23.5	28.2	32.9	37.6	42.4	47.1	51.8	56.5	61.2	65.9	70.6
8.75	4.6	9.1	13.7	18.3	22.9	27.4	32.0	36.6	41.1	45.7	50.3	54.9	59.4	64.0	68.6
9.00	4.4	8.9	13.3	17.8	22.2	26.7	31.1	35.6	40.0	44.4	48.9	53.3	57.8	62.2	66.7
9.25	4.3	8.6	13.0	17.3	21.6	25.9	30.3	34.6	38.9	43.2	47.6	51.9	56.2	60.5	64.9
9.50	4.2	8.4	12.6	16.8	21.1	25.3	29.5	33.7	37.9	42.1	46.3	50.5	54.7	58.9	63.2
9.75	4.1	8.2	12.3	16.4	20.5	24.6	28.7	32.8	36.9	41.0	45.1	49.2	53.3	57.4	61.5
10.00	4.0	8.0	12.0	16.0	20.0	24.0	28.0	32.0	36.0	40.0	44.0	48.0	52.0	56.0	60.0
10.50	3.8	7.6	11.4	15.2	19.0	22.9	26.7	30.5	34.3	38.1	41.9	45.7	49.5	53.3	57.1
11.00	3.6	7.3	10.9	14.5	18.2	21.8	25.5	29.1	32.7	36.4	40.0	43.6	47.3	50.9	54.5
11.50	3.5	7.0	10.4	13.9	17.4	20.9	24.3	27.8	31.3	34.8	38.3	41.7	45.2	48.7	52.2
12.00	3.3	6.7	10.0	13.3	16.7	20.0	23.3	26.7	30.0	33.3	36.7	40.0	43.3	46.7	50.0
12.50	3.2	6.4	9.6	12.8	16.0	19.2	22.4	25.6	28.8	32.0	35.2	38.4	41.6	44.8	48.0
13.00	3.1	6.2	9.2	12.3	15.4	18.5	21.5	24.6	27.7	30.8	33.8	36.9	40.0	43.1	46.2
13.50	3.0	5.9	8.9	11.9	14.8	17.8	20.7	23.7	26.7	29.6	32.6	35.6	38.5	41.5	44.4
14.00	2.9	5.7	8.6	11.4	14.3	17.1	20.0	22.9	25.7	28.6	31.4	34.3	37.1	40.0	42.9
14.50	2.8	5.5	8.3	11.0	13.8	16.6	19.3	22.1	24.8	27.6	30.3	33.1	35.9	38.6	41.4
15.00	2.7	5.3	8.0	10.7	13.3	16.0	18.7	21.3	24.0	26.7	29.3	32.0	34.7	37.3	40.0
15.50	2.6	5.2	7.7	10.3	12.9	15.5	18.1	20.6	23.2	25.8	28.4	31.0	33.5	36.1	38.7
16.00	2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0	27.5	30.0	32.5	35.0	37.5
16.50	2.4	4.8	7.3	9.7	12.1	14.5	17.0	19.4	21.8	24.2	26.7	29.1	31.5	33.9	36.4
17.00	2.4	4.7	7.1	9.4	11.8	14.1	16.5	18.8	21.2	23.5	25.9	28.2	30.6	32.9	35.3
17.50	2.3	4.6	6.9	9.1	11.4	13.7	16.0	18.3	20.6	22.9	25.1	27.4	29.7	32.0	34.3
18.00	2.2	4.4	6.7	8.9	11.1	13.3	15.6	17.8	20.0	22.2	24.4	26.7	28.9	31.1	33.3
18.50	2.2	4.3	6.5	8.6	10.8	13.0	15.1	17.3	19.5	21.6	23.8	25.9	28.1	30.3	32.4
19.00	2.1	4.2	6.3	8.4	10.5	12.6	14.7	16.8	18.9	21.1	23.2	25.3	27.4	29.5	31.6
19.50	2.1	4.1	6.2	8.2	10.3	12.3	14.4	16.4	18.5	20.5	22.6	24.6	26.7	28.7	30.8
20.00	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0	26.0	28.0	30.0

Charge densities ($\mu\text{C}/\text{cm}^2$) for exposed stimulation areas from 1.5 to 20 mm^2 , stimulation current amplitudes from 1 to 15 mA and a phase length of 500 μs .

Exposed stimulation area (mm^2)	Current amplitude (mA)														
	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0
1.50	33.3	66.7	100.0	133.3	166.7	200.0	233.3	266.7	300.0	333.3	366.7	400.0	433.3	466.7	500.0
1.75	28.6	57.1	85.7	114.3	142.9	171.4	200.0	228.6	257.1	285.7	314.3	342.9	371.4	400.0	428.6
2.00	25.0	50.0	75.0	100.0	125.0	150.0	175.0	200.0	225.0	250.0	275.0	300.0	325.0	350.0	375.0
2.25	22.2	44.4	66.7	88.9	111.1	133.3	155.6	177.8	200.0	222.2	244.4	266.7	288.9	311.1	333.3
2.50	20.0	40.0	60.0	80.0	100.0	120.0	140.0	160.0	180.0	200.0	220.0	240.0	260.0	280.0	300.0
2.75	18.2	36.4	54.5	72.7	90.9	109.1	127.3	145.5	163.6	181.8	200.0	218.2	236.4	254.5	272.7
3.00	16.7	33.3	50.0	66.7	83.3	100.0	116.7	133.3	150.0	166.7	183.3	200.0	216.7	233.3	250.0
3.25	15.4	30.8	46.2	61.5	76.9	92.3	107.7	123.1	138.5	153.8	169.2	184.6	200.0	215.4	230.8
3.50	14.3	28.6	42.9	57.1	71.4	85.7	100.0	114.3	128.6	142.9	157.1	171.4	185.7	200.0	214.3
3.75	13.3	26.7	40.0	53.3	66.7	80.0	93.3	106.7	120.0	133.3	146.7	160.0	173.3	186.7	200.0
4.00	12.5	25.0	37.5	50.0	62.5	75.0	87.5	100.0	112.5	125.0	137.5	150.0	162.5	175.0	187.5
4.25	11.8	23.5	35.3	47.1	58.8	70.6	82.4	94.1	105.9	117.6	129.4	141.2	152.9	164.7	176.5
4.50	11.1	22.2	33.3	44.4	55.6	66.7	77.8	88.9	100.0	111.1	122.2	133.3	144.4	155.6	166.7
4.75	10.5	21.1	31.6	42.1	52.6	63.2	73.7	84.2	94.7	105.3	115.8	126.3	136.8	147.4	157.9
5.00	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	110.0	120.0	130.0	140.0	150.0
5.25	9.5	19.0	28.6	38.1	47.6	57.1	66.7	76.2	85.7	95.2	104.8	114.3	123.8	133.3	142.9
5.50	9.1	18.2	27.3	36.4	45.5	54.5	63.6	72.7	81.8	90.9	100.0	109.1	118.2	127.3	136.4
5.75	8.7	17.4	26.1	34.8	43.5	52.2	60.9	69.6	78.3	87.0	95.7	104.3	113.0	121.7	130.4
6.00	8.3	16.7	25.0	33.3	41.7	50.0	58.3	66.7	75.0	83.3	91.7	100.0	108.3	116.7	125.0
6.25	8.0	16.0	24.0	32.0	40.0	48.0	56.0	64.0	72.0	80.0	88.0	96.0	104.0	112.0	120.0
6.50	7.7	15.4	23.1	30.8	38.5	46.2	53.8	61.5	69.2	76.9	84.6	92.3	100.0	107.7	115.4
6.75	7.4	14.8	22.2	29.6	37.0	44.4	51.9	59.3	66.7	74.1	81.5	88.9	96.3	103.7	111.1
7.00	7.1	14.3	21.4	28.6	35.7	42.9	50.0	57.1	64.3	71.4	78.6	85.7	92.9	100.0	107.1
7.25	6.9	13.8	20.7	27.6	34.5	41.4	48.3	55.2	62.1	69.0	75.9	82.8	89.7	96.6	103.4
7.50	6.7	13.3	20.0	26.7	33.3	40.0	46.7	53.3	60.0	66.7	73.3	80.0	86.7	93.3	100.0
7.75	6.5	12.9	19.4	25.8	32.3	38.7	45.2	51.6	58.1	64.5	71.0	77.4	83.9	90.3	96.8
8.00	6.3	12.5	18.8	25.0	31.3	37.5	43.8	50.0	56.3	62.5	68.8	75.0	81.3	87.5	93.8
8.25	6.1	12.1	18.2	24.2	30.3	36.4	42.4	48.5	54.5	60.6	66.7	72.7	78.8	84.8	90.9
8.50	5.9	11.8	17.6	23.5	29.4	35.3	41.2	47.1	52.9	58.8	64.7	70.6	76.5	82.4	88.2
8.75	5.7	11.4	17.1	22.9	28.6	34.3	40.0	45.7	51.4	57.1	62.9	68.6	74.3	80.0	85.7
9.00	5.6	11.1	16.7	22.2	27.8	33.3	38.9	44.4	50.0	55.6	61.1	66.7	72.2	77.8	83.3
9.25	5.4	10.8	16.2	21.6	27.0	32.4	37.8	43.2	48.6	54.1	59.5	64.9	70.3	75.7	81.1
9.50	5.3	10.5	15.8	21.1	26.3	31.6	36.8	42.1	47.4	52.6	57.9	63.2	68.4	73.7	78.9
9.75	5.1	10.3	15.4	20.5	25.6	30.8	35.9	41.0	46.2	51.3	56.4	61.5	66.7	71.8	76.9
10.00	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0	65.0	70.0	75.0
10.50	4.8	9.5	14.3	19.0	23.8	28.6	33.3	38.1	42.9	47.6	52.4	57.1	61.9	66.7	71.4
11.00	4.5	9.1	13.6	18.2	22.7	27.3	31.8	36.4	40.9	45.5	50.0	54.5	59.1	63.6	68.2
11.50	4.3	8.7	13.0	17.4	21.7	26.1	30.4	34.8	39.1	43.5	47.8	52.2	56.5	60.9	65.2
12.00	4.2	8.3	12.5	16.7	20.8	25.0	29.2	33.3	37.5	41.7	45.8	50.0	54.2	58.3	62.5
12.50	4.0	8.0	12.0	16.0	20.0	24.0	28.0	32.0	36.0	40.0	44.0	48.0	52.0	56.0	60.0
13.00	3.8	7.7	11.5	15.4	19.2	23.1	26.9	30.8	34.6	38.5	42.3	46.2	50.0	53.8	57.7
13.50	3.7	7.4	11.1	14.8	18.5	22.2	25.9	29.6	33.3	37.0	40.7	44.4	48.1	51.9	55.6
14.00	3.6	7.1	10.7	14.3	17.9	21.4	25.0	28.6	32.1	35.7	39.3	42.9	46.4	50.0	53.6
14.50	3.4	6.9	10.3	13.8	17.2	20.7	24.1	27.6	31.0	34.5	37.9	41.4	44.8	48.3	51.7
15.00	3.3	6.7	10.0	13.3	16.7	20.0	23.3	26.7	30.0	33.3	36.7	40.0	43.3	46.7	50.0
15.50	3.2	6.5	9.7	12.9	16.1	19.4	22.6	25.8	29.0	32.3	35.5	38.7	41.9	45.2	48.4
16.00	3.1	6.3	9.4	12.5	15.6	18.8	21.9	25.0	28.1	31.3	34.4	37.5	40.6	43.8	46.9
16.50	3.0	6.1	9.1	12.1	15.2	18.2	21.2	24.2	27.3	30.3	33.3	36.4	39.4	42.4	45.5
17.00	2.9	5.9	8.8	11.8	14.7	17.6	20.6	23.5	26.5	29.4	32.4	35.3	38.2	41.2	44.1
17.50	2.9	5.7	8.6	11.4	14.3	17.1	20.0	22.9	25.7	28.6	31.4	34.3	37.1	40.0	42.9
18.00	2.8	5.6	8.3	11.1	13.9	16.7	19.4	22.2	25.0	27.8	30.6	33.3	36.1	38.9	41.7
18.50	2.7	5.4	8.1	10.8	13.5	16.2	18.9	21.6	24.3	27.0	29.7	32.4	35.1	37.8	40.5
19.00	2.6	5.3	7.9	10.5	13.2	15.8	18.4	21.1	23.7	26.3	28.9	31.6	34.2	36.8	39.5
19.50	2.6	5.1	7.7	10.3	12.8	15.4	17.9	20.5	23.1	25.6	28.2	30.8	33.3	35.9	38.5
20.00	2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0	27.5	30.0	32.5	35.0	37.5

Charge densities ($\mu\text{C}/\text{cm}^2$) for exposed stimulation areas from 1.5 to 20 mm^2 , stimulation current amplitudes from 1 to 15 mA and a phase length of 600 μs .

Exposed stimulation area (mm^2)	Current amplitude (mA)														
	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0
1.50	40.0	80.0	120.0	160.0	200.0	240.0	280.0	320.0	360.0	400.0	440.0	480.0	520.0	560.0	600.0
1.75	34.3	68.6	102.9	137.1	171.4	205.7	240.0	274.3	308.6	342.9	377.1	411.4	445.7	480.0	514.3
2.00	30.0	60.0	90.0	120.0	150.0	180.0	210.0	240.0	270.0	300.0	330.0	360.0	390.0	420.0	450.0
2.25	26.7	53.3	80.0	106.7	133.3	160.0	186.7	213.3	240.0	266.7	293.3	320.0	346.7	373.3	400.0
2.50	24.0	48.0	72.0	96.0	120.0	144.0	168.0	192.0	216.0	240.0	264.0	288.0	312.0	336.0	360.0
2.75	21.8	43.6	65.5	87.3	109.1	130.9	152.7	174.5	196.4	218.2	240.0	261.8	283.6	305.5	327.3
3.00	20.0	40.0	60.0	80.0	100.0	120.0	140.0	160.0	180.0	200.0	220.0	240.0	260.0	280.0	300.0
3.25	18.5	36.9	55.4	73.8	92.3	110.8	129.2	147.7	166.2	184.6	203.1	221.5	240.0	258.5	276.9
3.50	17.1	34.3	51.4	68.6	85.7	102.9	120.0	137.1	154.3	171.4	188.6	205.7	222.9	240.0	257.1
3.75	16.0	32.0	48.0	64.0	80.0	96.0	112.0	128.0	144.0	160.0	176.0	192.0	208.0	224.0	240.0
4.00	15.0	30.0	45.0	60.0	75.0	90.0	105.0	120.0	135.0	150.0	165.0	180.0	195.0	210.0	225.0
4.25	14.1	28.2	42.4	56.5	70.6	84.7	98.8	112.9	127.1	141.2	155.3	169.4	183.5	197.6	211.8
4.50	13.3	26.7	40.0	53.3	66.7	80.0	93.3	106.7	120.0	133.3	146.7	160.0	173.3	186.7	200.0
4.75	12.6	25.3	37.9	50.5	63.2	75.8	88.4	101.1	113.7	126.3	138.9	151.6	164.2	176.8	189.5
5.00	12.0	24.0	36.0	48.0	60.0	72.0	84.0	96.0	108.0	120.0	132.0	144.0	156.0	168.0	180.0
5.25	11.4	22.9	34.3	45.7	57.1	68.6	80.0	91.4	102.9	114.3	125.7	137.1	148.6	160.0	171.4
5.50	10.9	21.8	32.7	43.6	54.5	65.5	76.4	87.3	98.2	109.1	120.0	130.9	141.8	152.7	163.6
5.75	10.4	20.9	31.3	41.7	52.2	62.6	73.0	83.5	93.9	104.3	114.8	125.2	135.7	146.1	156.5
6.00	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	110.0	120.0	130.0	140.0	150.0
6.25	9.6	19.2	28.8	38.4	48.0	57.6	67.2	76.8	86.4	96.0	105.6	115.2	124.8	134.4	144.0
6.50	9.2	18.5	27.7	36.9	46.2	55.4	64.6	73.8	83.1	92.3	101.5	110.8	120.0	129.2	138.5
6.75	8.9	17.8	26.7	35.6	44.4	53.3	62.2	71.1	80.0	88.9	97.8	106.7	115.6	124.4	133.3
7.00	8.6	17.1	25.7	34.3	42.9	51.4	60.0	68.6	77.1	85.7	94.3	102.9	111.4	120.0	128.6
7.25	8.3	16.6	24.8	33.1	41.4	49.7	57.9	66.2	74.5	82.8	91.0	99.3	107.6	115.9	124.1
7.50	8.0	16.0	24.0	32.0	40.0	48.0	56.0	64.0	72.0	80.0	88.0	96.0	104.0	112.0	120.0
7.75	7.7	15.5	23.2	31.0	38.7	46.5	54.2	61.9	69.7	77.4	85.2	92.9	100.6	108.4	116.1
8.00	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	97.5	105.0	112.5
8.25	7.3	14.5	21.8	29.1	36.4	43.6	50.9	58.2	65.5	72.7	80.0	87.3	94.5	101.8	109.1
8.50	7.1	14.1	21.2	28.2	35.3	42.4	49.4	56.5	63.5	70.6	77.6	84.7	91.8	98.8	105.9
8.75	6.9	13.7	20.6	27.4	34.3	41.1	48.0	54.9	61.7	68.6	75.4	82.3	89.1	96.0	102.9
9.00	6.7	13.3	20.0	26.7	33.3	40.0	46.7	53.3	60.0	66.7	73.3	80.0	86.7	93.3	100.0
9.25	6.5	13.0	19.5	25.9	32.4	38.9	45.4	51.9	58.4	64.9	71.4	77.8	84.3	90.8	97.3
9.50	6.3	12.6	18.9	25.3	31.6	37.9	44.2	50.5	56.8	63.2	69.5	75.8	82.1	88.4	94.7
9.75	6.2	12.3	18.5	24.6	30.8	36.9	43.1	49.2	55.4	61.5	67.7	73.8	80.0	86.2	92.3
10.00	6.0	12.0	18.0	24.0	30.0	36.0	42.0	48.0	54.0	60.0	66.0	72.0	78.0	84.0	90.0
10.50	5.7	11.4	17.1	22.9	28.6	34.3	40.0	45.7	51.4	57.1	62.9	68.6	74.3	80.0	85.7
11.00	5.5	10.9	16.4	21.8	27.3	32.7	38.2	43.6	49.1	54.5	60.0	65.5	70.9	76.4	81.8
11.50	5.2	10.4	15.7	20.9	26.1	31.3	36.5	41.7	47.0	52.2	57.4	62.6	67.8	73.0	78.3
12.00	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0	65.0	70.0	75.0
12.50	4.8	9.6	14.4	19.2	24.0	28.8	33.6	38.4	43.2	48.0	52.8	57.6	62.4	67.2	72.0
13.00	4.6	9.2	13.8	18.5	23.1	27.7	32.3	36.9	41.5	46.2	50.8	55.4	60.0	64.6	69.2
13.50	4.4	8.9	13.3	17.8	22.2	26.7	31.1	35.6	40.0	44.4	48.9	53.3	57.8	62.2	66.7
14.00	4.3	8.6	12.9	17.1	21.4	25.7	30.0	34.3	38.6	42.9	47.1	51.4	55.7	60.0	64.3
14.50	4.1	8.3	12.4	16.6	20.7	24.8	29.0	33.1	37.2	41.4	45.5	49.7	53.8	57.9	62.1
15.00	4.0	8.0	12.0	16.0	20.0	24.0	28.0	32.0	36.0	40.0	44.0	48.0	52.0	56.0	60.0
15.50	3.9	7.7	11.6	15.5	19.4	23.2	27.1	31.0	34.8	38.7	42.6	46.5	50.3	54.2	58.1
16.00	3.8	7.5	11.3	15.0	18.8	22.5	26.3	30.0	33.8	37.5	41.3	45.0	48.8	52.5	56.3
16.50	3.6	7.3	10.9	14.5	18.2	21.8	25.5	29.1	32.7	36.4	40.0	43.6	47.3	50.9	54.5
17.00	3.5	7.1	10.6	14.1	17.6	21.2	24.7	28.2	31.8	35.3	38.8	42.4	45.9	49.4	52.9
17.50	3.4	6.9	10.3	13.7	17.1	20.6	24.0	27.4	30.9	34.3	37.7	41.1	44.6	48.0	51.4
18.00	3.3	6.7	10.0	13.3	16.7	20.0	23.3	26.7	30.0	33.3	36.7	40.0	43.3	46.7	50.0
18.50	3.2	6.5	9.7	13.0	16.2	19.5	22.7	25.9	29.2	32.4	35.7	38.9	42.2	45.4	48.6
19.00	3.2	6.3	9.5	12.6	15.8	18.9	22.1	25.3	28.4	31.6	34.7	37.9	41.1	44.2	47.4
19.50	3.1	6.2	9.2	12.3	15.4	18.5	21.5	24.6	27.7	30.8	33.8	36.9	40.0	43.1	46.2
20.00	3.0	6.0	9.0	12.0	15.0	18.0	21.0	24.0	27.0	30.0	33.0	36.0	39.0	42.0	45.0

Charge densities ($\mu\text{C}/\text{cm}^2$) for exposed stimulation areas from 1.5 to 20 mm^2 , stimulation current amplitudes from 1 to 15 mA and a phase length of 700 μs .

Exposed stimulation area (mm^2)	Current amplitude (mA)														
	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0
1.50	46.7	93.3	140.0	186.7	233.3	280.0	326.7	373.3	420.0	466.7	513.3	560.0	606.7	653.3	700.0
1.75	40.0	80.0	120.0	160.0	200.0	240.0	280.0	320.0	360.0	400.0	440.0	480.0	520.0	560.0	600.0
2.00	35.0	70.0	105.0	140.0	175.0	210.0	245.0	280.0	315.0	350.0	385.0	420.0	455.0	490.0	525.0
2.25	31.1	62.2	93.3	124.4	155.6	186.7	217.8	248.9	280.0	311.1	342.2	373.3	404.4	435.6	466.7
2.50	28.0	56.0	84.0	112.0	140.0	168.0	196.0	224.0	252.0	280.0	308.0	336.0	364.0	392.0	420.0
2.75	25.5	50.9	76.4	101.8	127.3	152.7	178.2	203.6	229.1	254.5	280.0	305.5	330.9	356.4	381.8
3.00	23.3	46.7	70.0	93.3	116.7	140.0	163.3	186.7	210.0	233.3	256.7	280.0	303.3	326.7	350.0
3.25	21.5	43.1	64.6	86.2	107.7	129.2	150.8	172.3	193.8	215.4	236.9	258.5	280.0	301.5	323.1
3.50	20.0	40.0	60.0	80.0	100.0	120.0	140.0	160.0	180.0	200.0	220.0	240.0	260.0	280.0	300.0
3.75	18.7	37.3	56.0	74.7	93.3	112.0	130.7	149.3	168.0	186.7	205.3	224.0	242.7	261.3	280.0
4.00	17.5	35.0	52.5	70.0	87.5	105.0	122.5	140.0	157.5	175.0	192.5	210.0	227.5	245.0	262.5
4.25	16.5	32.9	49.4	65.9	82.4	98.8	115.3	131.8	148.2	164.7	181.2	197.6	214.1	230.6	247.1
4.50	15.6	31.1	46.7	62.2	77.8	93.3	108.9	124.4	140.0	155.6	171.1	186.7	202.2	217.8	233.3
4.75	14.7	29.5	44.2	58.9	73.7	88.4	103.2	117.9	132.6	147.4	162.1	176.8	191.6	206.3	221.1
5.00	14.0	28.0	42.0	56.0	70.0	84.0	98.0	112.0	126.0	140.0	154.0	168.0	182.0	196.0	210.0
5.25	13.3	26.7	40.0	53.3	66.7	80.0	93.3	106.7	120.0	133.3	146.7	160.0	173.3	186.7	200.0
5.50	12.7	25.5	38.2	50.9	63.6	76.4	89.1	101.8	114.5	127.3	140.0	152.7	165.5	178.2	190.9
5.75	12.2	24.3	36.5	48.7	60.9	73.0	85.2	97.4	109.6	121.7	133.9	146.1	158.3	170.4	182.6
6.00	11.7	23.3	35.0	46.7	58.3	70.0	81.7	93.3	105.0	116.7	128.3	140.0	151.7	163.3	175.0
6.25	11.2	22.4	33.6	44.8	56.0	67.2	78.4	89.6	100.8	112.0	123.2	134.4	145.6	156.8	168.0
6.50	10.8	21.5	32.3	43.1	53.8	64.6	75.4	86.2	96.9	107.7	118.5	129.2	140.0	150.8	161.5
6.75	10.4	20.7	31.1	41.5	51.9	62.2	72.6	83.0	93.3	103.7	114.1	124.4	134.8	145.2	155.6
7.00	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	110.0	120.0	130.0	140.0	150.0
7.25	9.7	19.3	29.0	38.6	48.3	57.9	67.6	77.2	86.9	96.6	106.2	115.9	125.5	135.2	144.8
7.50	9.3	18.7	28.0	37.3	46.7	56.0	65.3	74.7	84.0	93.3	102.7	112.0	121.3	130.7	140.0
7.75	9.0	18.1	27.1	36.1	45.2	54.2	63.2	72.3	81.3	90.3	99.4	108.4	117.4	126.5	135.5
8.00	8.8	17.5	26.3	35.0	43.8	52.5	61.3	70.0	78.8	87.5	96.3	105.0	113.8	122.5	131.3
8.25	8.5	17.0	25.5	33.9	42.4	50.9	59.4	67.9	76.4	84.8	93.3	101.8	110.3	118.8	127.3
8.50	8.2	16.5	24.7	32.9	41.2	49.4	57.6	65.9	74.1	82.4	90.6	98.8	107.1	115.3	123.5
8.75	8.0	16.0	24.0	32.0	40.0	48.0	56.0	64.0	72.0	80.0	88.0	96.0	104.0	112.0	120.0
9.00	7.8	15.6	23.3	31.1	38.9	46.7	54.4	62.2	70.0	77.8	85.6	93.3	101.1	108.9	116.7
9.25	7.6	15.1	22.7	30.3	37.8	45.4	53.0	60.5	68.1	75.7	83.2	90.8	98.4	105.9	113.5
9.50	7.4	14.7	22.1	29.5	36.8	44.2	51.6	58.9	66.3	73.7	81.1	88.4	95.8	103.2	110.5
9.75	7.2	14.4	21.5	28.7	35.9	43.1	50.3	57.4	64.6	71.8	79.0	86.2	93.3	100.5	107.7
10.00	7.0	14.0	21.0	28.0	35.0	42.0	49.0	56.0	63.0	70.0	77.0	84.0	91.0	98.0	105.0
10.50	6.7	13.3	20.0	26.7	33.3	40.0	46.7	53.3	60.0	66.7	73.3	80.0	86.7	93.3	100.0
11.00	6.4	12.7	19.1	25.5	31.8	38.2	44.5	50.9	57.3	63.6	70.0	76.4	82.7	89.1	95.5
11.50	6.1	12.2	18.3	24.3	30.4	36.5	42.6	48.7	54.8	60.9	67.0	73.0	79.1	85.2	91.3
12.00	5.8	11.7	17.5	23.3	29.2	35.0	40.8	46.7	52.5	58.3	64.2	70.0	75.8	81.7	87.5
12.50	5.6	11.2	16.8	22.4	28.0	33.6	39.2	44.8	50.4	56.0	61.6	67.2	72.8	78.4	84.0
13.00	5.4	10.8	16.2	21.5	26.9	32.3	37.7	43.1	48.5	53.8	59.2	64.6	70.0	75.4	80.8
13.50	5.2	10.4	15.6	20.7	25.9	31.1	36.3	41.5	46.7	51.9	57.0	62.2	67.4	72.6	77.8
14.00	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0	65.0	70.0	75.0
14.50	4.8	9.7	14.5	19.3	24.1	29.0	33.8	38.6	43.4	48.3	53.1	57.9	62.8	67.6	72.4
15.00	4.7	9.3	14.0	18.7	23.3	28.0	32.7	37.3	42.0	46.7	51.3	56.0	60.7	65.3	70.0
15.50	4.5	9.0	13.5	18.1	22.6	27.1	31.6	36.1	40.6	45.2	49.7	54.2	58.7	63.2	67.7
16.00	4.4	8.8	13.1	17.5	21.9	26.3	30.6	35.0	39.4	43.8	48.1	52.5	56.9	61.3	65.6
16.50	4.2	8.5	12.7	17.0	21.2	25.5	29.7	33.9	38.2	42.4	46.7	50.9	55.2	59.4	63.6
17.00	4.1	8.2	12.4	16.5	20.6	24.7	28.8	32.9	37.1	41.2	45.3	49.4	53.5	57.6	61.8
17.50	4.0	8.0	12.0	16.0	20.0	24.0	28.0	32.0	36.0	40.0	44.0	48.0	52.0	56.0	60.0
18.00	3.9	7.8	11.7	15.6	19.4	23.3	27.2	31.1	35.0	38.9	42.8	46.7	50.6	54.4	58.3
18.50	3.8	7.6	11.4	15.1	18.9	22.7	26.5	30.3	34.1	37.8	41.6	45.4	49.2	53.0	56.8
19.00	3.7	7.4	11.1	14.7	18.4	22.1	25.8	29.5	33.2	36.8	40.5	44.2	47.9	51.6	55.3
19.50	3.6	7.2	10.8	14.4	17.9	21.5	25.1	28.7	32.3	35.9	39.5	43.1	46.7	50.3	53.8
20.00	3.5	7.0	10.5	14.0	17.5	21.0	24.5	28.0	31.5	35.0	38.5	42.0	45.5	49.0	52.5

Charge densities ($\mu\text{C}/\text{cm}^2$) for exposed stimulation areas from 1.5 to 20 mm^2 , stimulation current amplitudes from 1 to 15 mA and a phase length of 800 μs .

Exposed stimulation area (mm^2)	Current amplitude (mA)														
	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0
1.50	53.3	106.7	160.0	213.3	266.7	320.0	373.3	426.7	480.0	533.3	586.7	640.0	693.3	746.7	800.0
1.75	45.7	91.4	137.1	182.9	228.6	274.3	320.0	365.7	411.4	457.1	502.9	548.6	594.3	640.0	685.7
2.00	40.0	80.0	120.0	160.0	200.0	240.0	280.0	320.0	360.0	400.0	440.0	480.0	520.0	560.0	600.0
2.25	35.6	71.1	106.7	142.2	177.8	213.3	248.9	284.4	320.0	355.6	391.1	426.7	462.2	497.8	533.3
2.50	32.0	64.0	96.0	128.0	160.0	192.0	224.0	256.0	288.0	320.0	352.0	384.0	416.0	448.0	480.0
2.75	29.1	58.2	87.3	116.4	145.5	174.5	203.6	232.7	261.8	290.9	320.0	349.1	378.2	407.3	436.4
3.00	26.7	53.3	80.0	106.7	133.3	160.0	186.7	213.3	240.0	266.7	293.3	320.0	346.7	373.3	400.0
3.25	24.6	49.2	73.8	98.5	123.1	147.7	172.3	196.9	221.5	246.2	270.8	295.4	320.0	344.6	369.2
3.50	22.9	45.7	68.6	91.4	114.3	137.1	160.0	182.9	205.7	228.6	251.4	274.3	297.1	320.0	342.9
3.75	21.3	42.7	64.0	85.3	106.7	128.0	149.3	170.7	192.0	213.3	234.7	256.0	277.3	298.7	320.0
4.00	20.0	40.0	60.0	80.0	100.0	120.0	140.0	160.0	180.0	200.0	220.0	240.0	260.0	280.0	300.0
4.25	18.8	37.6	56.5	75.3	94.1	112.9	131.8	150.6	169.4	188.2	207.1	225.9	244.7	263.5	282.4
4.50	17.8	35.6	53.3	71.1	88.9	106.7	124.4	142.2	160.0	177.8	195.6	213.3	231.1	248.9	266.7
4.75	16.8	33.7	50.5	67.4	84.2	101.1	117.9	134.7	151.6	168.4	185.3	202.1	218.9	235.8	252.6
5.00	16.0	32.0	48.0	64.0	80.0	96.0	112.0	128.0	144.0	160.0	176.0	192.0	208.0	224.0	240.0
5.25	15.2	30.5	45.7	61.0	76.2	91.4	106.7	121.9	137.1	152.4	167.6	182.9	198.1	213.3	228.6
5.50	14.5	29.1	43.6	58.2	72.7	87.3	101.8	116.4	130.9	145.5	160.0	174.5	189.1	203.6	218.2
5.75	13.9	27.8	41.7	55.7	69.6	83.5	97.4	111.3	125.2	139.1	153.0	167.0	180.9	194.8	208.7
6.00	13.3	26.7	40.0	53.3	66.7	80.0	93.3	106.7	120.0	133.3	146.7	160.0	173.3	186.7	200.0
6.25	12.8	25.6	38.4	51.2	64.0	76.8	89.6	102.4	115.2	128.0	140.8	153.6	166.4	179.2	192.0
6.50	12.3	24.6	36.9	49.2	61.5	73.8	86.2	98.5	110.8	123.1	135.4	147.7	160.0	172.3	184.6
6.75	11.9	23.7	35.6	47.4	59.3	71.1	83.0	94.8	106.7	118.5	130.4	142.2	154.1	165.9	177.8
7.00	11.4	22.9	34.3	45.7	57.1	68.6	80.0	91.4	102.9	114.3	125.7	137.1	148.6	160.0	171.4
7.25	11.0	22.1	33.1	44.1	55.2	66.2	77.2	88.3	99.3	110.3	121.4	132.4	143.4	154.5	165.5
7.50	10.7	21.3	32.0	42.7	53.3	64.0	74.7	85.3	96.0	106.7	117.3	128.0	138.7	149.3	160.0
7.75	10.3	20.6	31.0	41.3	51.6	61.9	72.3	82.6	92.9	103.2	113.5	123.9	134.2	144.5	154.8
8.00	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	110.0	120.0	130.0	140.0	150.0
8.25	9.7	19.4	29.1	38.8	48.5	58.2	67.9	77.6	87.3	97.0	106.7	116.4	126.1	135.8	145.5
8.50	9.4	18.8	28.2	37.6	47.1	56.5	65.9	75.3	84.7	94.1	103.5	112.9	122.4	131.8	141.2
8.75	9.1	18.3	27.4	36.6	45.7	54.9	64.0	73.1	82.3	91.4	100.6	109.7	118.9	128.0	137.1
9.00	8.9	17.8	26.7	35.6	44.4	53.3	62.2	71.1	80.0	88.9	97.8	106.7	115.6	124.4	133.3
9.25	8.6	17.3	25.9	34.6	43.2	51.9	60.5	69.2	77.8	86.5	95.1	103.8	112.4	121.1	129.7
9.50	8.4	16.8	25.3	33.7	42.1	50.5	58.9	67.4	75.8	84.2	92.6	101.1	109.5	117.9	126.3
9.75	8.2	16.4	24.6	32.8	41.0	49.2	57.4	65.6	73.8	82.1	90.3	98.5	106.7	114.9	123.1
10.00	8.0	16.0	24.0	32.0	40.0	48.0	56.0	64.0	72.0	80.0	88.0	96.0	104.0	112.0	120.0
10.50	7.6	15.2	22.9	30.5	38.1	45.7	53.3	61.0	68.6	76.2	83.8	91.4	99.0	106.7	114.3
11.00	7.3	14.5	21.8	29.1	36.4	43.6	50.9	58.2	65.5	72.7	80.0	87.3	94.5	101.8	109.1
11.50	7.0	13.9	20.9	27.8	34.8	41.7	48.7	55.7	62.6	69.6	76.5	83.5	90.4	97.4	104.3
12.00	6.7	13.3	20.0	26.7	33.3	40.0	46.7	53.3	60.0	66.7	73.3	80.0	86.7	93.3	100.0
12.50	6.4	12.8	19.2	25.6	32.0	38.4	44.8	51.2	57.6	64.0	70.4	76.8	83.2	89.6	96.0
13.00	6.2	12.3	18.5	24.6	30.8	36.9	43.1	49.2	55.4	61.5	67.7	73.8	80.0	86.2	92.3
13.50	5.9	11.9	17.8	23.7	29.6	35.6	41.5	47.4	53.3	59.3	65.2	71.1	77.0	83.0	88.9
14.00	5.7	11.4	17.1	22.9	28.6	34.3	40.0	45.7	51.4	57.1	62.9	68.6	74.3	80.0	85.7
14.50	5.5	11.0	16.6	22.1	27.6	33.1	38.6	44.1	49.7	55.2	60.7	66.2	71.7	77.2	82.8
15.00	5.3	10.7	16.0	21.3	26.7	32.0	37.3	42.7	48.0	53.3	58.7	64.0	69.3	74.7	80.0
15.50	5.2	10.3	15.5	20.6	25.8	31.0	36.1	41.3	46.5	51.6	56.8	61.9	67.1	72.3	77.4
16.00	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0	65.0	70.0	75.0
16.50	4.8	9.7	14.5	19.4	24.2	29.1	33.9	38.8	43.6	48.5	53.3	58.2	63.0	67.9	72.7
17.00	4.7	9.4	14.1	18.8	23.5	28.2	32.9	37.6	42.4	47.1	51.8	56.5	61.2	65.9	70.6
17.50	4.6	9.1	13.7	18.3	22.9	27.4	32.0	36.6	41.1	45.7	50.3	54.9	59.4	64.0	68.6
18.00	4.4	8.9	13.3	17.8	22.2	26.7	31.1	35.6	40.0	44.4	48.9	53.3	57.8	62.2	66.7
18.50	4.3	8.6	13.0	17.3	21.6	25.9	30.3	34.6	38.9	43.2	47.6	51.9	56.2	60.5	64.9
19.00	4.2	8.4	12.6	16.8	21.1	25.3	29.5	33.7	37.9	42.1	46.3	50.5	54.7	58.9	63.2
19.50	4.1	8.2	12.3	16.4	20.5	24.6	28.7	32.8	36.9	41.0	45.1	49.2	53.3	57.4	61.5
20.00	4.0	8.0	12.0	16.0	20.0	24.0	28.0	32.0	36.0	40.0	44.0	48.0	52.0	56.0	60.0

Charge densities ($\mu\text{C}/\text{cm}^2$) for exposed stimulation areas from 1.5 to 20 mm^2 , stimulation current amplitudes from 1 to 15 mA and a phase length of 900 μs .

Exposed stimulation area (mm^2)	Current amplitude (mA)														
	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0
1.50	60.0	120.0	180.0	240.0	300.0	360.0	420.0	480.0	540.0	600.0	660.0	720.0	780.0	840.0	900.0
1.75	51.4	102.9	154.3	205.7	257.1	308.6	360.0	411.4	462.9	514.3	565.7	617.1	668.6	720.0	771.4
2.00	45.0	90.0	135.0	180.0	225.0	270.0	315.0	360.0	405.0	450.0	495.0	540.0	585.0	630.0	675.0
2.25	40.0	80.0	120.0	160.0	200.0	240.0	280.0	320.0	360.0	400.0	440.0	480.0	520.0	560.0	600.0
2.50	36.0	72.0	108.0	144.0	180.0	216.0	252.0	288.0	324.0	360.0	396.0	432.0	468.0	504.0	540.0
2.75	32.7	65.5	98.2	130.9	163.6	196.4	229.1	261.8	294.5	327.3	360.0	392.7	425.5	458.2	490.9
3.00	30.0	60.0	90.0	120.0	150.0	180.0	210.0	240.0	270.0	300.0	330.0	360.0	390.0	420.0	450.0
3.25	27.7	55.4	83.1	110.8	138.5	166.2	193.8	221.5	249.2	276.9	304.6	332.3	360.0	387.7	415.4
3.50	25.7	51.4	77.1	102.9	128.6	154.3	180.0	205.7	231.4	257.1	282.9	308.6	334.3	360.0	385.7
3.75	24.0	48.0	72.0	96.0	120.0	144.0	168.0	192.0	216.0	240.0	264.0	288.0	312.0	336.0	360.0
4.00	22.5	45.0	67.5	90.0	112.5	135.0	157.5	180.0	202.5	225.0	247.5	270.0	292.5	315.0	337.5
4.25	21.2	42.4	63.5	84.7	105.9	127.1	148.2	169.4	190.6	211.8	232.9	254.1	275.3	296.5	317.6
4.50	20.0	40.0	60.0	80.0	100.0	120.0	140.0	160.0	180.0	200.0	220.0	240.0	260.0	280.0	300.0
4.75	18.9	37.9	56.8	75.8	94.7	113.7	132.6	151.6	170.5	189.5	208.4	227.4	246.3	265.3	284.2
5.00	18.0	36.0	54.0	72.0	90.0	108.0	126.0	144.0	162.0	180.0	198.0	216.0	234.0	252.0	270.0
5.25	17.1	34.3	51.4	68.6	85.7	102.9	120.0	137.1	154.3	171.4	188.6	205.7	222.9	240.0	257.1
5.50	16.4	32.7	49.1	65.5	81.8	98.2	114.5	130.9	147.3	163.6	180.0	196.4	212.7	229.1	245.5
5.75	15.7	31.3	47.0	62.6	78.3	93.9	109.6	125.2	140.9	156.5	172.2	187.8	203.5	219.1	234.8
6.00	15.0	30.0	45.0	60.0	75.0	90.0	105.0	120.0	135.0	150.0	165.0	180.0	195.0	210.0	225.0
6.25	14.4	28.8	43.2	57.6	72.0	86.4	100.8	115.2	129.6	144.0	158.4	172.8	187.2	201.6	216.0
6.50	13.8	27.7	41.5	55.4	69.2	83.1	96.9	110.8	124.6	138.5	152.3	166.2	180.0	193.8	207.7
6.75	13.3	26.7	40.0	53.3	66.7	80.0	93.3	106.7	120.0	133.3	146.7	160.0	173.3	186.7	200.0
7.00	12.9	25.7	38.6	51.4	64.3	77.1	90.0	102.9	115.7	128.6	141.4	154.3	167.1	180.0	192.9
7.25	12.4	24.8	37.2	49.7	62.1	74.5	86.9	99.3	111.7	124.1	136.6	149.0	161.4	173.8	186.2
7.50	12.0	24.0	36.0	48.0	60.0	72.0	84.0	96.0	108.0	120.0	132.0	144.0	156.0	168.0	180.0
7.75	11.6	23.2	34.8	46.5	58.1	69.7	81.3	92.9	104.5	116.1	127.7	139.4	151.0	162.6	174.2
8.00	11.3	22.5	33.8	45.0	56.3	67.5	78.8	90.0	101.3	112.5	123.8	135.0	146.3	157.5	168.8
8.25	10.9	21.8	32.7	43.6	54.5	65.5	76.4	87.3	98.2	109.1	120.0	130.9	141.8	152.7	163.6
8.50	10.6	21.2	31.8	42.4	52.9	63.5	74.1	84.7	95.3	105.9	116.5	127.1	137.6	148.2	158.8
8.75	10.3	20.6	30.9	41.1	51.4	61.7	72.0	82.3	92.6	102.9	113.1	123.4	133.7	144.0	154.3
9.00	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	110.0	120.0	130.0	140.0	150.0
9.25	9.7	19.5	29.2	38.9	48.6	58.4	68.1	77.8	87.6	97.3	107.0	116.8	126.5	136.2	145.9
9.50	9.5	18.9	28.4	37.9	47.4	56.8	66.3	75.8	85.3	94.7	104.2	113.7	123.2	132.6	142.1
9.75	9.2	18.5	27.7	36.9	46.2	55.4	64.6	73.8	83.1	92.3	101.5	110.8	120.0	129.2	138.5
10.00	9.0	18.0	27.0	36.0	45.0	54.0	63.0	72.0	81.0	90.0	99.0	108.0	117.0	126.0	135.0
10.50	8.6	17.1	25.7	34.3	42.9	51.4	60.0	68.6	77.1	85.7	94.3	102.9	111.4	120.0	128.6
11.00	8.2	16.4	24.5	32.7	40.9	49.1	57.3	65.5	73.6	81.8	90.0	98.2	106.4	114.5	122.7
11.50	7.8	15.7	23.5	31.3	39.1	47.0	54.8	62.6	70.4	78.3	86.1	93.9	101.7	109.6	117.4
12.00	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0	82.5	90.0	97.5	105.0	112.5
12.50	7.2	14.4	21.6	28.8	36.0	43.2	50.4	57.6	64.8	72.0	79.2	86.4	93.6	100.8	108.0
13.00	6.9	13.8	20.8	27.7	34.6	41.5	48.5	55.4	62.3	69.2	76.2	83.1	90.0	96.9	103.8
13.50	6.7	13.3	20.0	26.7	33.3	40.0	46.7	53.3	60.0	66.7	73.3	80.0	86.7	93.3	100.0
14.00	6.4	12.9	19.3	25.7	32.1	38.6	45.0	51.4	57.9	64.3	70.7	77.1	83.6	90.0	96.4
14.50	6.2	12.4	18.6	24.8	31.0	37.2	43.4	49.7	55.9	62.1	68.3	74.5	80.7	86.9	93.1
15.00	6.0	12.0	18.0	24.0	30.0	36.0	42.0	48.0	54.0	60.0	66.0	72.0	78.0	84.0	90.0
15.50	5.8	11.6	17.4	23.2	29.0	34.8	40.6	46.5	52.3	58.1	63.9	69.7	75.5	81.3	87.1
16.00	5.6	11.3	16.9	22.5	28.1	33.8	39.4	45.0	50.6	56.3	61.9	67.5	73.1	78.8	84.4
16.50	5.5	10.9	16.4	21.8	27.3	32.7	38.2	43.6	49.1	54.5	60.0	65.5	70.9	76.4	81.8
17.00	5.3	10.6	15.9	21.2	26.5	31.8	37.1	42.4	47.6	52.9	58.2	63.5	68.8	74.1	79.4
17.50	5.1	10.3	15.4	20.6	25.7	30.9	36.0	41.1	46.3	51.4	56.6	61.7	66.9	72.0	77.1
18.00	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0	65.0	70.0	75.0
18.50	4.9	9.7	14.6	19.5	24.3	29.2	34.1	38.9	43.8	48.6	53.5	58.4	63.2	68.1	73.0
19.00	4.7	9.5	14.2	18.9	23.7	28.4	33.2	37.9	42.6	47.4	52.1	56.8	61.6	66.3	71.1
19.50	4.6	9.2	13.8	18.5	23.1	27.7	32.3	36.9	41.5	46.2	50.8	55.4	60.0	64.6	69.2
20.00	4.5	9.0	13.5	18.0	22.5	27.0	31.5	36.0	40.5	45.0	49.5	54.0	58.5	63.0	67.5

Charge densities ($\mu\text{C}/\text{cm}^2$) for exposed stimulation areas from 1.5 to 20 mm^2 , stimulation current amplitudes from 1 to 15 mA and a phase length of 1000 μs .

Exposed stimulation area (mm^2)	Current amplitude (mA)														
	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0
1.50	66.7	133.3	200.0	266.7	333.3	400.0	466.7	533.3	600.0	666.7	733.3	800.0	866.7	933.3	1000.0
1.75	57.1	114.3	171.4	228.6	285.7	342.9	400.0	457.1	514.3	571.4	628.6	685.7	742.9	800.0	857.1
2.00	50.0	100.0	150.0	200.0	250.0	300.0	350.0	400.0	450.0	500.0	550.0	600.0	650.0	700.0	750.0
2.25	44.4	88.9	133.3	177.8	222.2	266.7	311.1	355.6	400.0	444.4	488.9	533.3	577.8	622.2	666.7
2.50	40.0	80.0	120.0	160.0	200.0	240.0	280.0	320.0	360.0	400.0	440.0	480.0	520.0	560.0	600.0
2.75	36.4	72.7	109.1	145.5	181.8	218.2	254.5	290.9	327.3	363.6	400.0	436.4	472.7	509.1	545.5
3.00	33.3	66.7	100.0	133.3	166.7	200.0	233.3	266.7	300.0	333.3	366.7	400.0	433.3	466.7	500.0
3.25	30.8	61.5	92.3	123.1	153.8	184.6	215.4	246.2	276.9	307.7	338.5	369.2	400.0	430.8	461.5
3.50	28.6	57.1	85.7	114.3	142.9	171.4	200.0	228.6	257.1	285.7	314.3	342.9	371.4	400.0	428.6
3.75	26.7	53.3	80.0	106.7	133.3	160.0	186.7	213.3	240.0	266.7	293.3	320.0	346.7	373.3	400.0
4.00	25.0	50.0	75.0	100.0	125.0	150.0	175.0	200.0	225.0	250.0	275.0	300.0	325.0	350.0	375.0
4.25	23.5	47.1	70.6	94.1	117.6	141.2	164.7	188.2	211.8	235.3	258.8	282.4	305.9	329.4	352.9
4.50	22.2	44.4	66.7	88.9	111.1	133.3	155.6	177.8	200.0	222.2	244.4	266.7	288.9	311.1	333.3
4.75	21.1	42.1	63.2	84.2	105.3	126.3	147.4	168.4	189.5	210.5	231.6	252.6	273.7	294.7	315.8
5.00	20.0	40.0	60.0	80.0	100.0	120.0	140.0	160.0	180.0	200.0	220.0	240.0	260.0	280.0	300.0
5.25	19.0	38.1	57.1	76.2	95.2	114.3	133.3	152.4	171.4	190.5	209.5	228.6	247.6	266.7	285.7
5.50	18.2	36.4	54.5	72.7	90.9	109.1	127.3	145.5	163.6	181.8	200.0	218.2	236.4	254.5	272.7
5.75	17.4	34.8	52.2	69.6	87.0	104.3	121.7	139.1	156.5	173.9	191.3	208.7	226.1	243.5	260.9
6.00	16.7	33.3	50.0	66.7	83.3	100.0	116.7	133.3	150.0	166.7	183.3	200.0	216.7	233.3	250.0
6.25	16.0	32.0	48.0	64.0	80.0	96.0	112.0	128.0	144.0	160.0	176.0	192.0	208.0	224.0	240.0
6.50	15.4	30.8	46.2	61.5	76.9	92.3	107.7	123.1	138.5	153.8	169.2	184.6	200.0	215.4	230.8
6.75	14.8	29.6	44.4	59.3	74.1	88.9	103.7	118.5	133.3	148.1	163.0	177.8	192.6	207.4	222.2
7.00	14.3	28.6	42.9	57.1	71.4	85.7	100.0	114.3	128.6	142.9	157.1	171.4	185.7	200.0	214.3
7.25	13.8	27.6	41.4	55.2	69.0	82.8	96.6	110.3	124.1	137.9	151.7	165.5	179.3	193.1	206.9
7.50	13.3	26.7	40.0	53.3	66.7	80.0	93.3	106.7	120.0	133.3	146.7	160.0	173.3	186.7	200.0
7.75	12.9	25.8	38.7	51.6	64.5	77.4	90.3	103.2	116.1	129.0	141.9	154.8	167.7	180.6	193.5
8.00	12.5	25.0	37.5	50.0	62.5	75.0	87.5	100.0	112.5	125.0	137.5	150.0	162.5	175.0	187.5
8.25	12.1	24.2	36.4	48.5	60.6	72.7	84.8	97.0	109.1	121.2	133.3	145.5	157.6	169.7	181.8
8.50	11.8	23.5	35.3	47.1	58.8	70.6	82.4	94.1	105.9	117.6	129.4	141.2	152.9	164.7	176.5
8.75	11.4	22.9	34.3	45.7	57.1	68.6	80.0	91.4	102.9	114.3	125.7	137.1	148.6	160.0	171.4
9.00	11.1	22.2	33.3	44.4	55.6	66.7	77.8	88.9	100.0	111.1	122.2	133.3	144.4	155.6	166.7
9.25	10.8	21.6	32.4	43.2	54.1	64.9	75.7	86.5	97.3	108.1	118.9	129.7	140.5	151.4	162.2
9.50	10.5	21.1	31.6	42.1	52.6	63.2	73.7	84.2	94.7	105.3	115.8	126.3	136.8	147.4	157.9
9.75	10.3	20.5	30.8	41.0	51.3	61.5	71.8	82.1	92.3	102.6	112.8	123.1	133.3	143.6	153.8
10.00	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	110.0	120.0	130.0	140.0	150.0
10.50	9.5	19.0	28.6	38.1	47.6	57.1	66.7	76.2	85.7	95.2	104.8	114.3	123.8	133.3	142.9
11.00	9.1	18.2	27.3	36.4	45.5	54.5	63.6	72.7	81.8	90.9	100.0	109.1	118.2	127.3	136.4
11.50	8.7	17.4	26.1	34.8	43.5	52.2	60.9	69.6	78.3	87.0	95.7	104.3	113.0	121.7	130.4
12.00	8.3	16.7	25.0	33.3	41.7	50.0	58.3	66.7	75.0	83.3	91.7	100.0	108.3	116.7	125.0
12.50	8.0	16.0	24.0	32.0	40.0	48.0	56.0	64.0	72.0	80.0	88.0	96.0	104.0	112.0	120.0
13.00	7.7	15.4	23.1	30.8	38.5	46.2	53.8	61.5	69.2	76.9	84.6	92.3	100.0	107.7	115.4
13.50	7.4	14.8	22.2	29.6	37.0	44.4	51.9	59.3	66.7	74.1	81.5	88.9	96.3	103.7	111.1
14.00	7.1	14.3	21.4	28.6	35.7	42.9	50.0	57.1	64.3	71.4	78.6	85.7	92.9	100.0	107.1
14.50	6.9	13.8	20.7	27.6	34.5	41.4	48.3	55.2	62.1	69.0	75.9	82.8	89.7	96.6	103.4
15.00	6.7	13.3	20.0	26.7	33.3	40.0	46.7	53.3	60.0	66.7	73.3	80.0	86.7	93.3	100.0
15.50	6.5	12.9	19.4	25.8	32.3	38.7	45.2	51.6	58.1	64.5	71.0	77.4	83.9	90.3	96.8
16.00	6.3	12.5	18.8	25.0	31.3	37.5	43.8	50.0	56.3	62.5	68.8	75.0	81.3	87.5	93.8
16.50	6.1	12.1	18.2	24.2	30.3	36.4	42.4	48.5	54.5	60.6	66.7	72.7	78.8	84.8	90.9
17.00	5.9	11.8	17.6	23.5	29.4	35.3	41.2	47.1	52.9	58.8	64.7	70.6	76.5	82.4	88.2
17.50	5.7	11.4	17.1	22.9	28.6	34.3	40.0	45.7	51.4	57.1	62.9	68.6	74.3	80.0	85.7
18.00	5.6	11.1	16.7	22.2	27.8	33.3	38.9	44.4	50.0	55.6	61.1	66.7	72.2	77.8	83.3
18.50	5.4	10.8	16.2	21.6	27.0	32.4	37.8	43.2	48.6	54.1	59.5	64.9	70.3	75.7	81.1
19.00	5.3	10.5	15.8	21.1	26.3	31.6	36.8	42.1	47.4	52.6	57.9	63.2	68.4	73.7	78.9
19.50	5.1	10.3	15.4	20.5	25.6	30.8	35.9	41.0	46.2	51.3	56.4	61.5	66.7	71.8	76.9
20.00	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0	65.0	70.0	75.0

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