

Standard Operating Procedure for Using DS7A Digitimer in BUCNI

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Stimulation Introduction

This document is aimed at researchers that wish to use the DS7A electrical stimulator in the Birkbeck-UCL Centre for Neuroimaging (BUCNI) scanner.

The objective is to produce a safe operating environment, and to highlight those steps necessary to safely operate the stimulator for the purpose of electrical stimulation of a volunteer. Joerg Magerkurth must train and guide you through the use of the DS7A.

The electrical stimulators are used to provide a time and magnitude controlled stimulus (shock) to a subject. Misuse of such equipment can be **dangerous** to a subject, therefore should you (the researcher) wish to proceed in your investigation utilizing a stimulator, and then the question you need to consider is:

What steps must one follow when one wishes to safely electrically stimulate a volunteer?

The following sections aim to describe in detail all necessary aspects of electrical stimulation, and how it may be performed safely.

Safe Practice

- **Before using the DS7A please ensure that you have read and understood the Digitimer user manual and this document.**
- **Ensure your volunteer is suitable for Electrical Stimulation prior to commencing!**
- **Some medical conditions may prevent the use of the Digitimer!!!**
Important exclusion criteria include Cardiac disorders, neurostimulator, pacemaker, uncontrolled Hyperthyroidism, severe hypertension and significant skin conditions in the region of intended stimulation (e.g. eczema, psoriasis). Other conditions may prevent the use of the Digitimer. Seek advice and **if you are unsure do not continue!**
- Other sources of information can be found in the Reference section.

Standard Operating Procedure

To use DS7A you must be a BUCNI certified user and must have been trained by Joerg Magerkurth to use DS7A. You must use the DS7A only within BUCNI.



Fig 1

DS7A- See Digitimer Manual for comprehensive description

I. Equipment

1. DS7A is available for use in the BUCNI scanner but will require setting up and training prior to use (See Joerg Magerkurth). The DS7A is classed as non-standard equipment.
2. DS7A is powered from the Lucas LSLC22-12G (12v 22Ah/20Hr) battery and CE approved WAECO MSI 212 (150W power output) inverter, see Fig 2a and 2b.



Fig 2a, Lucas LSLC22-12G (12v 22Ah/20Hr) battery



Fig 2b, WAECO SinePower MSI 212

3. Prior to the arrival of the volunteer the system must be set up correctly and tested. The following items must be checked:
 - a) The trigger cable from DS7A is connected via a fiber optic cable (see Fig 3a and 3b) to the parallel port of Stimulus PC (Cogent PC).

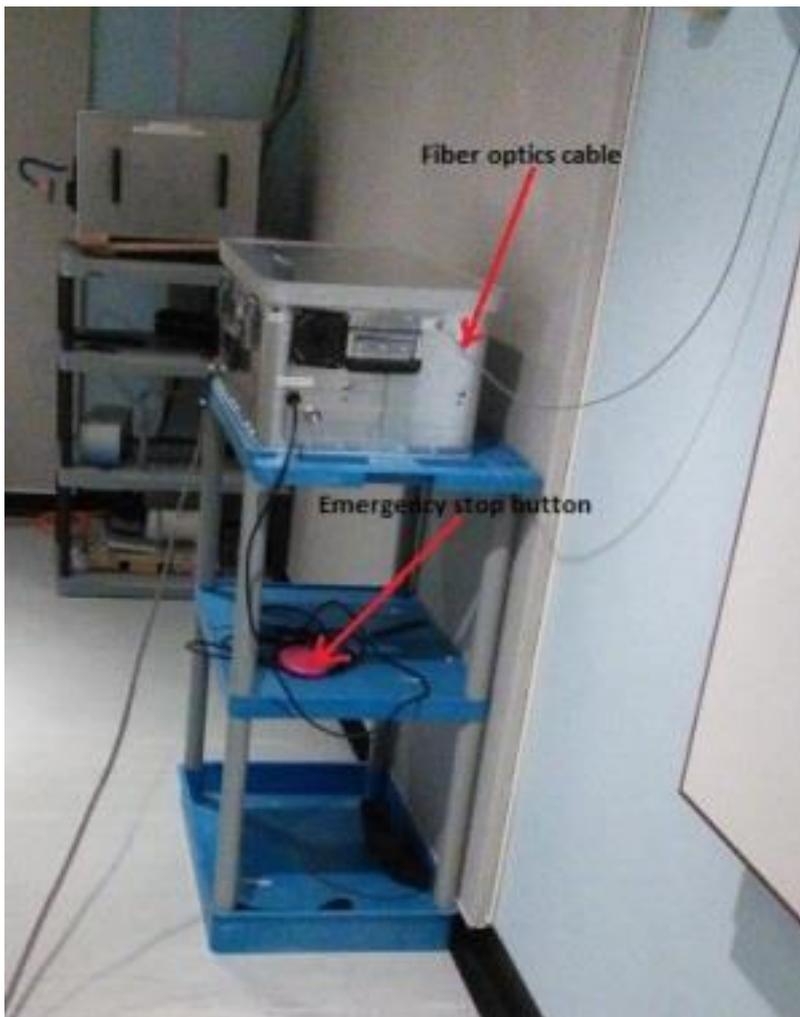


Fig 3a

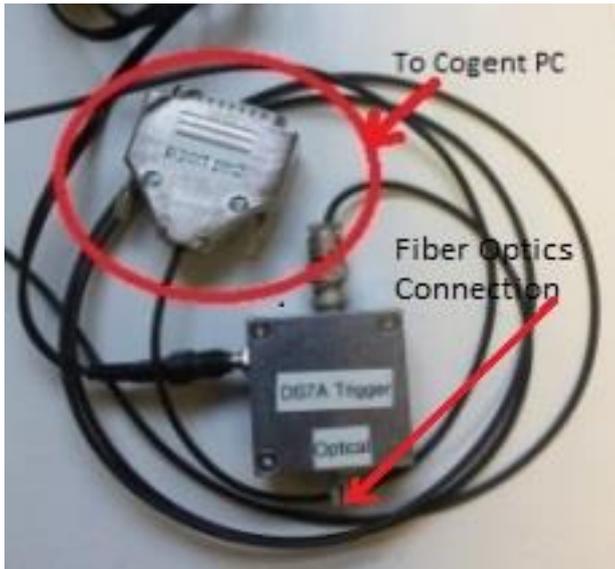


Fig 3b, Trigger cable

- b) All the cables and connections appear securely plugged in, (see Fig 4a, 4b). If you are unsure please check with Joerg Magerkurth.



Fig 4a, DS7A front connections

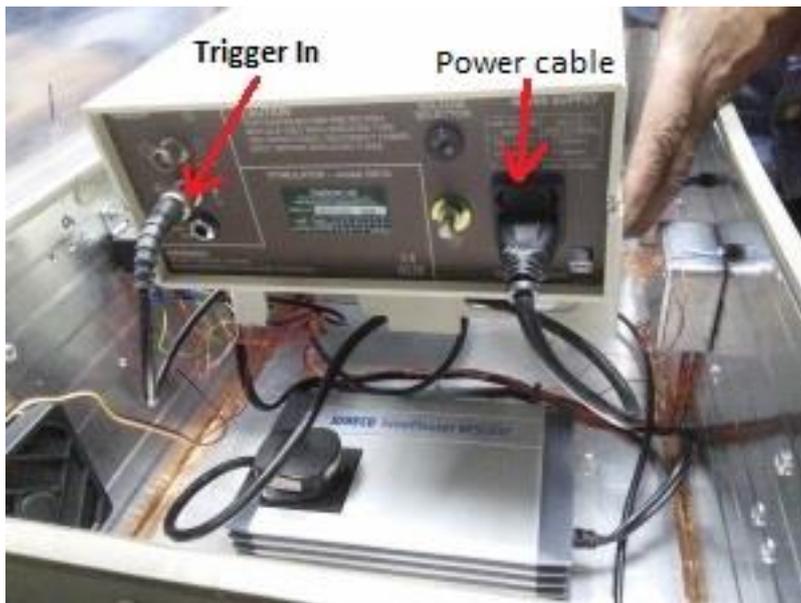


Fig 4b, DS7A rear connections

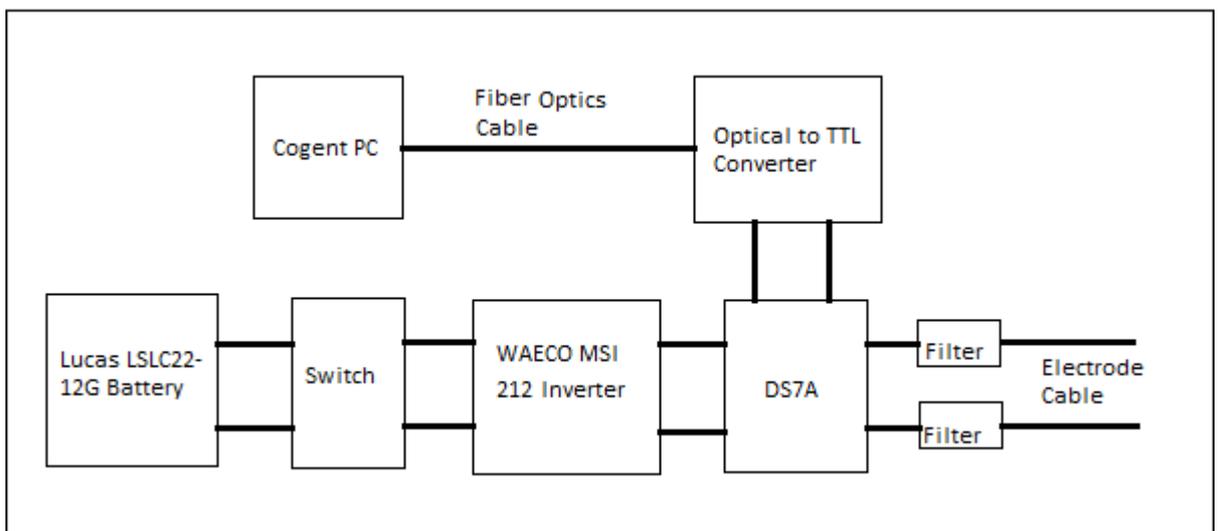


Fig 4c, Connection diagram of Current Stimulator

- c) There should be plenty of space in the scanner around the subject to perform the task and no other equipment should be in the vicinity during the electrical stimulation
- d) DS7A is highly magnetic and kept inside an aluminium box and make sure that the blue table unit, where the aluminium box is placed should be as shown in figure 5, see the marker on the floor.



Fig

5, where the blue table unit is placed

- e) Nothing should be placed on the blue table unit except the electrode cable.
4. Ensure all controls on the DS7A are set to the required level according to experimental design as disclosed and approved at project presentation. **Ensure the current amplitude dial is reading ZERO before commencing and the x1/x10 Switch is set to x1 (see Fig 6). N.B. Output Enable Switch should be OFF (fig 12) to isolate the patient from the electronics of the unit. Current range selection switch, x1 is appropriate, Consult with Joerg Magerkurth if you need to use x10.**



Fig 6

II. Procedure for Applying Electrode

1. Ensure that the electrode is placed correctly. Please check the following:
 - a) Ensure that the correct electrode is used: Note that the “Electrical Stimulation is through the skin, (“Percutaneous Stimulation”) the use of **Needle electrodes** is not permitted.
 - b) The diameter of the ring for the electrode must not be more than 2cm.
 - c) Electrode must be insulated and the subject told not to touch.
 - d) Subject must be asked if allergic to tin, copper and fiber glass.
 - e) Electrode gel used with electrical stimulation, see fig 7a. To place electrode on the subject, see section ‘Skin preparation and electrode placement’ on page 16.



Fig 7a, Spectra 360 Salt free Electrode Gel



Fig 7b, Electrode use in BUCNI

- f) The electrode lead must go along the centre of bore (see fig8) and they should be visually inspected before use.

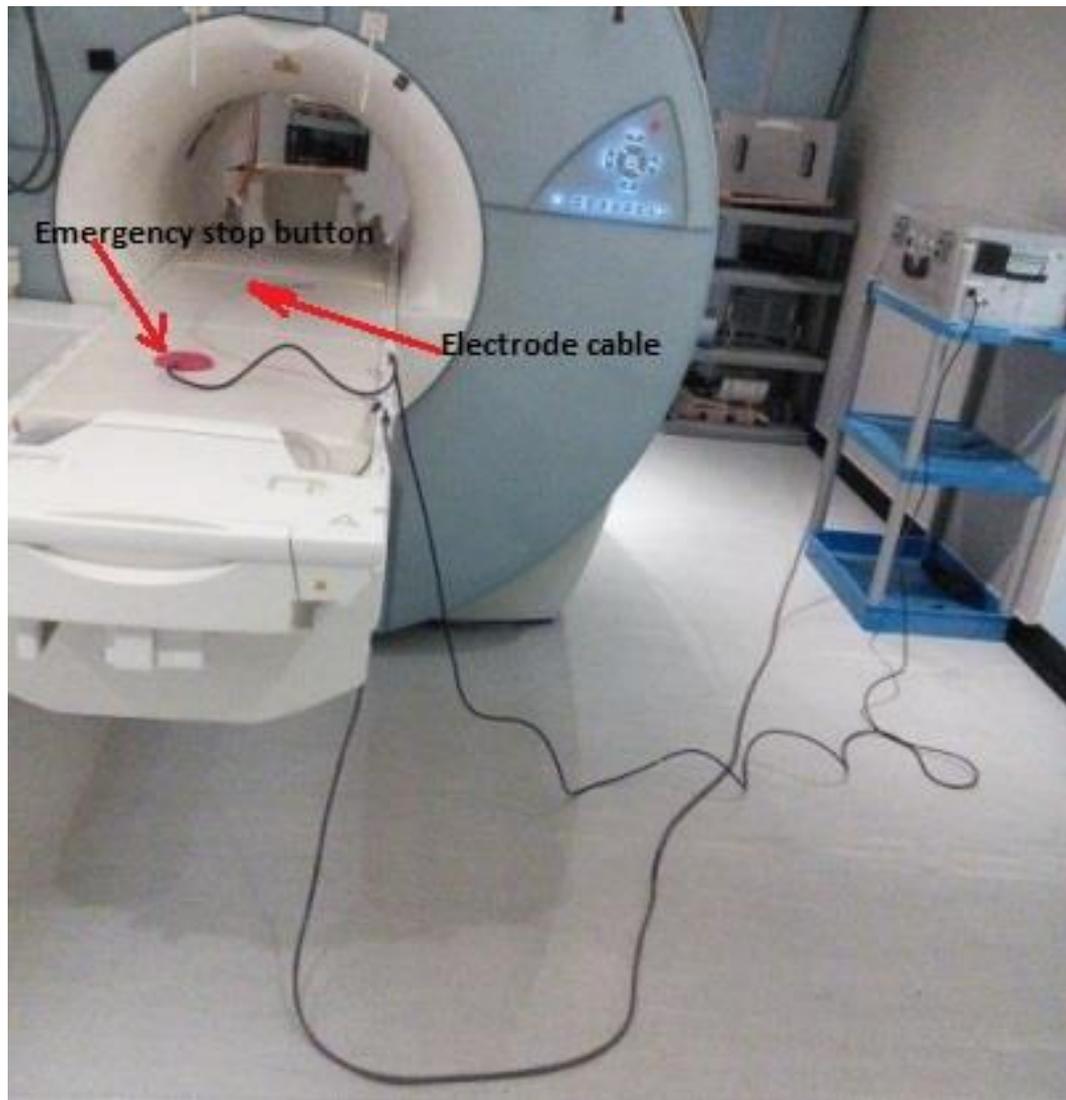


Figure 8, how the electrode cable going along the bore

2. Ask the volunteer lay comfortably. Warn the volunteer if the electrode stimulation becomes painful or there is any uncomfortable sensation different from the threshold testing to **inform you immediately!** First securely apply the electrode and then attach the electrode ends to the electrode extension cable, See Fig 9.



Fig 9, electrode extension cable

3. Next ensure that the electrode extension cable is connected to the BNC connectors on the aluminium box (follow colour coding), see Fig 10.



Fig 10

4. When all the above has been achieved and the volunteer is comfortable carry out threshold testing.

III. **Threshold Testing**

In order to carry out **threshold testing** the following procedure should be followed:

- a) Ensure the current dial is set to zero and the x1/x10 Switch is set to x1, see Fig 6.
- b) Explain to the volunteer what to expect in terms of sensation.
- c) Power on the device using ON/OFF switch (see Fig 11a) and the green LED comes on.



Fig 11a

- d) Switch on DS7A using START button (see Fig 11a) and the orange LED comes on. Note that the orange LED flashes if the DS7A is automatically turned off by pressing the emergency stop button (see fig 8).
- e) The emergency stop button will turn DS7A off and an alarm will be heard. The alarm can be turned off by pressing the RESET button (see fig 11a). Once the RESET button is pressed, to start DS7A, press START button again.
- f) Turn on Output Enable Switch (see Fig 12).

- g) Please reset the unit (DS7A) if a fault is indicated by the red LED (Fig 12). If the Output Enable Switch is on, it must be switched into the OFF position to reset the unit and then turn it back ON for using the device. If you don't understand why there is a fault, please ask Joerg Magerkurth.



Fig 12, Output Enable Switch

- h) Slowly turn up the current dial switch to the next test current value and **WARN** the volunteer before the TRIGGER button is pressed to test the stimulus level.
- i) **Do NOT** make large current jumps as this can be uncomfortable and painful for the volunteer, increase to the desired level in small steps.
- j) Voltage Amplitude Control (Fig 14) sets the maximum voltage that can occur on the electrode and is continuously variable between 100 – 400V. When the Out of Compliance indicated by the amber LED (next to the Voltage Amplitude Control) lit, indicates that the unit was unable to supply the current of the requested strength.
- k) When the threshold testing is complete ensure the volunteer is comfortable.

IV. Experiment

- a) Make sure that the **aluminium box is CLOSED** before starting the experiment (see Fig 3a). Otherwise the subject is in danger and your data will suffer. The electrode cable include 10K nonmagnetic resistors to protect the subject from severe burns.
- b) Test DS7A trigger from Cogent PC to see if it works. Whenever the DS7A receive a trigger input the white LED on the aluminium box flashes, see Fig 13
- c) **When in FMRI ensure that volunteer has access to the alarm bulb and the emergency stop button for DS7A** (see Fig 8).
- d) Ensure the volunteer is again made aware to inform you if they have ANY concern or feel ANY discomfort about the procedure.
- e) Start experiment

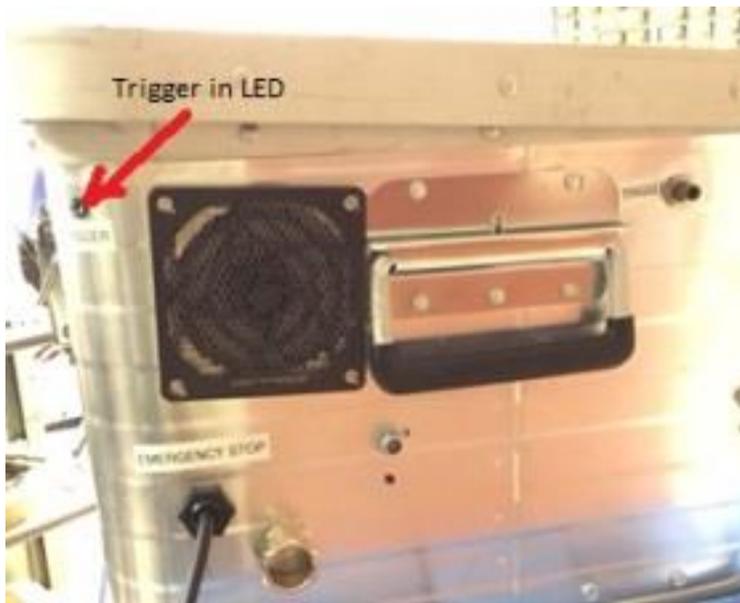


Fig 13

- f) At the end of the experiment-
- i. Remove the electrodes from the volunteer and wipe away any excess paste.
 - ii. **DS7A must have the current amplitude dial returned to zero and Output Enable Switch should be OFF** (Fig 6 and 12).
 - iii. Turn the system off using ON/OFF switch (Fig 11a)

DS7A Controls

A description of the controls follows;

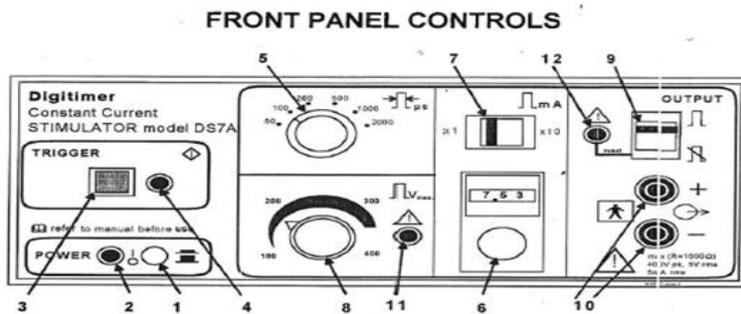


Fig 14

1. Mains Power ON/OFF switch (push ON, push OFF). When in the unit is on.
2. POWER ON is indicated by a green LED. When lit, indicates that the unit is on.
3. Manual trigger switch. Upon pressing this switch, a single output is produced.
4. A valid TRIGGER signal is indicated by a amber LED. A flash indicates a valid trigger signal - either from an external source or the manual push button.
5. Pulse Width switch that sets the width between 50 μ s and 2 ms (2000 μ s) in 6 steps.
6. Current Amplitude control of output pulses. This gives a continuously variable between 0 - 10 mA (or 0 - 100 mA if the x10 range is selected).
7. x1 and x10 RANGE selection switch. This gives either an output range of 0 - 10 mA, as indicated in the window of the Current Amplitude Control or 0 - 100 mA by multiplying Current Amplitude Control display by a factor of ten.
8. Voltage Amplitude Control of output pulses (maximum). This sets the maximum voltage that can occur on the electrodes and is continuously variable between 100 - 400 V.
9. Output Enable Switch. In the ON position, the unit is able to generate output pulses. In the OFF position the patient is isolated from the electronics of the unit. Switching to the OFF position also resets the FAULT indicator latch.
NB: This is not the primary power supply switch.
10. Isolated Output Sockets to patient stimulating electrodes. The RED (upper) socket will go positive with respect to the BLACK socket. The RED socket will be the ANODE.
11. OUT OF COMPLIANCE is indicated by an amber LED. When lit, indicates that the unit was unable to supply the current of the requested stimulus strength.
12. A FAULT is indicated by a red LED. When lit this indicates that the unit has detected a possible internal fault and should not be used. NB: As a test, this indicator will illuminate at power-on for a few seconds. If the Output Enable Switch (9) is ON, it must be switched into the OFF position to reset the circuitry before use of the unit.

REAR PANEL CONTROLS

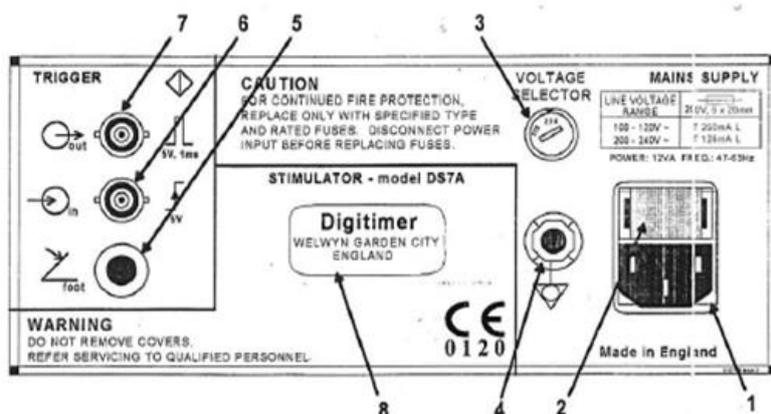


Fig 15

1. Mains inlet. Connect only to correct mains supply using supplied lead with moulded mains plug. **THIS UNIT MUST BE EARTHED.** The mains lead must contain the **PROTECTIVE EARTH CONDUCTOR.**
2. Mains fusing. Remove mains lead before opening. For continued electrical and fire safety, the correct fuses must be fitted before use of the unit.
3. Voltage selector allowing selection of local mains supply (115 or 230V). This must be correctly set before application of mains power to the unit.
4. Protective Earth Terminal (PET). This is an extra Earthing terminal to the **PROTECTIVE EARTH CONDUCTOR** that is the third wire in the mains cable. It is fitted to allow an earth reference for the unit and bonding point for connection to a **POTENTIAL EQUALISATION CONDUCTOR.**
5. Footswitch input allowing a footswitch to be used to trigger the unit.
6. TRIGGER IN socket that allows an external voltage change to trigger the unit (Logic signal (+3 to +15V) +ve edge, TTL compatible).
7. TRIGGER OUT socket that provides a trigger output pulse whenever the unit receives a valid TRIGGER IN.

Stimulus Control

The stimulator requires a TTL input (BNC I/p), and triggers on the +ve edge, a trigger output is provided through a BNC socket on the rear panel.

Three parameters are used by the DS7A to determine the strength of the stimulus:

1. **Pulse width:** - This is set via the 6 position switch on the front of the DS7A.
2. **Current:** - There are two controls (dial and x1/x10 switch) that enable the user to set the max stimulus current between 0mA to 100mA. The selected current can only be delivered if there is sufficient voltage available to support the selected value.
3. **Max voltage:** - The max voltage may be set using the control on the front panel, the user should aim to provide the smallest voltage necessary, that will deliver the required current, in this way the volunteer will not be subjected to larger stimulation currents than they are accustomed to.

In addition, the repetition rate at which the stimulator is triggered (e.g. by the stimulus PC), will also affect the strength of the stimulus.

Out of compliance indicator: Amber light beside voltage control.

- This indicator shows that the required stimulus was not supplied for some or all of the pulse duration time, this indicates that the voltage {V} is too low to maintain the required current.
- The stimulator attempts to deliver a constant current {I} to the impedance {Z} of the output (patient + inline resistance).
- If there is not a good connection of the electrodes onto the skin of the patient or if the voltage setting is too low, this indicator will be illuminated.
- Since $V(\text{max}) = I * R$
Then for given impedance, I will remain constant as long as
 $I * R < V$ (dial setting)

Stimulation from PC:

Stimulation is activated using the Matlab function shown below:

```
send_trigger(portaddr, numofpulse, delaybwpulse);
```

Arguments:-

portaddr : parallel port address in decimal, for LPT1 – 888. On BUCNI Cogent PC, the parallel port address is 53328 (or hex2dec('D050'))

numofpulse : number of triggers

delaybwpulse : delay between the triggers (ms). If more than one trigger, delay between the triggers should be $\geq 1\text{ms}$, max. trigger rate = 1khz.

If **numofpulse** = 1 then **delaybwpulse** = 0

e.g. `send_trigger(888,2,1000)`: - will send 2 trigger pulses in the interval of 1s

Electrodes

Only electrode shown in fig 7b is allowed in BUCNI. The following is a guidance for selecting electrodes. If you want to use any other electrodes that should be approved by Joerg Magerkurth. Electrodes must be carefully selected as their size and style greatly affect Current Density, which directly leads to a burning potential at the site of stimulation. Ensure the resistance of any electrodes is less than 10k ohms otherwise the stimulator will fail to produce the required stimulation current. Resistance of electrodes should be of the order of 1.5 - 2 ohms, and are unusable if they measure greater than 10k ohms when in place.

Electrode Material – For patient safety, Digitimer recommend that electrodes should be of a non-polarizable construction e.g. Ag/AgCl.

All electrodes should be used with series resistors in place; this will ensure that research paradigms may be used in the scanner with no changes.

Skin preparation and Electrode placement

Place electrodes on the subject according to these guidelines:

1. Prepare the subject's skin surface by abrading with skin prep gel (see Fig 7a) to create low contact source impedance at the electrode attachment site. Be careful to wipe away any excess electrode gel from the surface of the subject's skin.
2. Place electrode on the subject's skin. Please check the following:
 - a. The diameter of the ring for the electrode must not be more than 2cm.
 - b. Electrode must be insulated and the subject told not to touch.
 - c. The electrode lead must go along the centre of bore (see fig 8) and they should be visually inspected before use.
 - d. Subject must be asked if allergic to tin, copper and fiber glass.

Stimulator in the BUCNI Scanner

- Please read [BUCNI Manual](http://bucni.psychol.ucl.ac.uk/Forms/MRI-SafetyStatement-v14.pdf) (<http://bucni.psychol.ucl.ac.uk/Forms/MRI-SafetyStatement-v14.pdf>) and the [Essential Rules and Regulations at BUCNI](http://bucni.psychol.ucl.ac.uk/Bucni_Rules/index.shtml) (http://bucni.psychol.ucl.ac.uk/Bucni_Rules/index.shtml) before scanning.
- Please make sure that the scanner is booked for no more than 4 hours as the battery charge can last only 6 hours. The estimated time for empty battery to 80% charge is 2 hours (using CTEK MXS 7.0 Charger).
- **It is necessary to do physiological measurements to check the subject's pulse and breathing.**

How to Leave Digitimer after Use

- All DS7A dials should be set to zero on completion of the study.
- Output Enable Switch should be OFF
- Turn the system off using ON/OFF switch (Fig 11a)
- After your experiment, please ask Joerg Magerkurth to recharge the battery.

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*Numerous papers, abstracts and booklets are available from **Digitimer** - please see the website www.digitimer.com for the current list and request form.*