DMT
DANISH MYO TECHNOLOGY

CURRENT STIMULATOR

- COMBINED PULSE & TRAIN GENERATOR

MODEL CS200

User Manual

Version 1.8

CURRENT STIMULATOR
MODEL CS200

TRADEMARKS

DMT reserves the right to alter specifications as required.
This document was, as far as possible, accurate at the time of printing. Changes may have been made to the software and hardware it describes since then. New information may be supplied separately.

This documentation is provided with the DMT Current stimulator – Model CS200

Document number: CS200 002A

Every attempt is made to ensure accurate information, misprints, construction- and specification changes can occur. Danish Myo Technology A/S reserves the right to alter/change content as required and without any notice.

CONTENTS

SAFETY

The Current Generator has been designed for use only in teaching and research applications. It is not intended for clinical or critical life-care use and should never be used for these purposes: nor for the prevention, diagnosis, curing, treatment, or alleviation of disease, injury, or handicap.

- Do not open the unit: the internal electronics pose a risk of electric shock.
- Do not use this apparatus near water.
- To reduce the risk of fire or electric shock, do not expose this apparatus to rain or moisture. Objects filled with liquids should not be placed on the apparatus.
- Do not block any ventilation openings. Install in accordance with the manufacturer's instructions.
- Do not install near any heat sources such as radiators, heat registers, stoves, or other apparatus that produce heat.
- Only use attachments and accessories specified by the manufacturer.
- Unplug this apparatus during lightning storms or when unused for long periods of time.
- This apparatus must be grounded.
- Use a three-wire grounding-type cord similar to the one supplied with the product.
- Do not defeat the safety purpose of the polarized or grounding-type plug. A polarized plug has two flat blades, one being wider than the other. A grounding type plug has two blades and a third (round) grounding pin. The wide blade or the third prong is provided for your safety. If the provided plug does not fit into your outlet, consult an electrician for replacement of the obsolete outlet.
- Be advised that different operating voltages require the use of different types of line cord and attachment plugs. Check the voltage in your area and use the correct type. See the table below:

Voltage	**Line plug according to standard**
110–125 V	UL817 and CSA C22.2 No. 42
220–230 V	CEE 7 page VII, SR section 107-2-D1/IEC 83, page C4.
240 V	BS 1363 of 1984. Specification for 13A fused plugs and switched and unswitched socket outlets.

Protect the power cord from being walked on or pinched: particularly at power plugs and the point where they connect to the apparatus.

Refer all servicing to qualified service personnel. Servicing is required when the apparatus has been damaged in any way; such as, the power-supply cord or plug is damaged, liquid has spilled onto or objects have fallen into the apparatus, the apparatus has been exposed to rain or moisture, does not operate normally, or has been dropped.

EMC / EMI

This equipment has been tested and found to comply with the limits for a Class B Digital device, pursuant to part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in residential installations. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception (which can be determined by monitoring the interference while turning the equipment off and on), the user is encouraged to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different to that which the receiver is connected to.
- Consult the dealer or an experienced radio/TV technician for help.

APPROVALS

Complies with the EMC standards:	EMC 89/336/EEC: EN 50 081-1 and EN 50 082-1 FCC part 15, Class B CISPR 22, Class B
Certified with the safety standards:	EN 60 065 (IEC 60065)
Complies with the safety standards:	UL6500 CSA E65

CERTIFICATE OF CONFORMITY

DMT A/S, Skejbyparken 152, 8200 Aarhus N., Denmark,
hereby declares its responsibility that the following product:

Current Stimulator – Model CS200

is covered by this certificate and marked with CE-label conforms with the following standards:

EN 61010-1:2001 EN61010-1/Corr.1:2003 EN 61010-1/Corr.1:2003	Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 1: General requirements.
EN 61010-2-101:2003	Safety requirements for electrical equipment for measurement, control and laboratory use - Part 2-101: Particular requirements for in vitro diagnostic (IVD) medical equipment.
EN 61326-2-6:2005	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 2-6: Particular requirements - In vitro diagnostic (IVD) medical equipment.
	With reference to regulations in the following directives: 2006/95/EC, 89/336/EEC

ABOUT THIS MANUAL

This manual contains a complete list of procedures describing how to install, and get started using the Current stimulator unit – model CS200.

Chapter 1 provides an introduction to the construction and basic features of the Current stimulator unit.

Chapter 2 describes step-by-step how to install a Current stimulator unit.

Chapter 3 is a complete manual to the Current Stimulator Unit. The chapter describes in detail the construction of the menu system and how to use all the features of the Current Stimulator Unit.

Chapter 4 contains procedures describing how to set up a serial protocol and requesting data.

Appendix contain system specifications.

UNPACKING THE CURRENT STIMULATOR SYSTEM

Please take a few minutes to carefully inspect your new Current stimulator unit for damage, which may have occurred during handling and shipping. If you suspect any kind of damage, please contact us immediately and we will take care of the problems as quickly as possible. If the packing material appears damaged, please retain it until a possible claim has been settled.

We recommend that you store the packing material for any possible future transport of the Current stimulator unit. In case of transport and the original packing material is unavailable, please contact DMT Sales Department for advice and packing instructions.

After unpacking your new current stimulator unit please use the following list to check that the system is complete:

- 1 Current stimulator unit
- 1 power cord*
- 1 User manual

* The shape of the AC plug varies by country; be sure that the plug has the right shape for your location

CHAPTER 1 - INTRODUCTION

1.1 Document scope

This manual provides the information required to install and understand the principles of operating the CS200 combined pulse and train stimulator.

1.2 Product overview

The CS200 Current Stimulator combines simple and intuitive user operation with sophisticated features that are required in electro physiology. The CS200 is a modular and highly versatile 4 channel current stimulator designed for use in combination with DMT's Myograph systems. It is optimized for electrical field stimulation of vascular smooth muscle, isolated skeletal muscle, or cardiac muscle. Furthermore for controlled neurotransmitter release from perivascular nerve-endings or skeletal muscle motor nerve end plates.

The stimulator provides a variety of stimulation modes and protocols, such as single continuous and frequency regulated steps. All parameters are easily entered from the front panel and can be applied on an individual channel basis or to all channels simultaneously. Once the programmed protocols have been determined, they can be stored in one of five internal program memories to be re-loaded at any time. The CS200 can easily be connected to a computer using the standard serial port, either alone (using RS232 serial protocol) or in combination with up to 4 additional stimulators and maximal 4 myograph systems (using the RS485 serial protocol).

1.3 Features

The following features are common on the CS200 Current Stimulator.

- **Pulse stimulator:**
  - Pulse width 0.03 – 500ms
  - Current 0 – 100mA
  - Compliance 50 Volts
  - Rise/fall time 1.5µs
  - Output mono- or bi polar

- **Train stimulator:**
  - Frequency 0.1 – 256Hz
  - Train duration 0.1 – 3600s
  - Train delay 0.1-3600s

- **Frequency ramp**

- **Internal memory**
  - can store up to five user defined current waveform protocols

- **External control through serial communication (RS232/RS485)**

CHAPTER 2 - INSTALLATION PROCEDURE

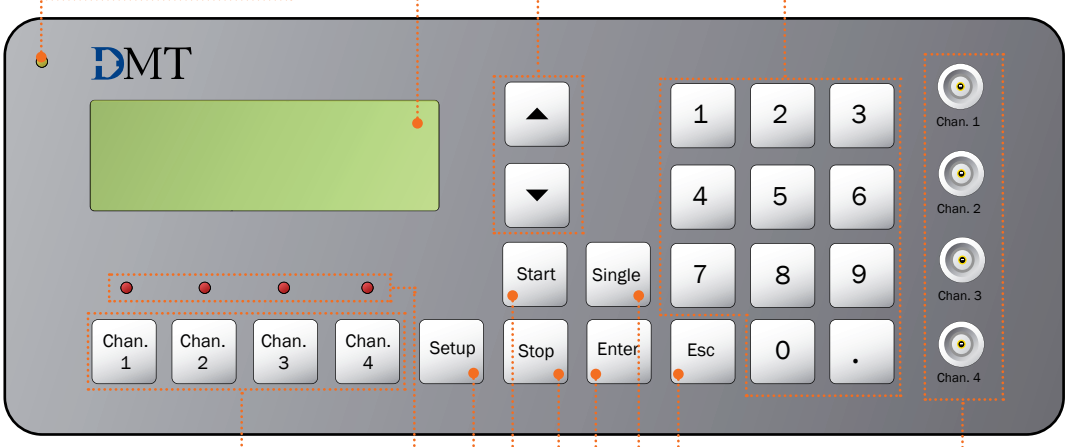
2.1 Current Stimulator front panel

LCD display
Channel and CS200 setup menu are displayed here.

Power indicator
A yellow LED indicates power switched ON.

Up and down arrows
Will move the cursor in the display to the next or previous menu-item.

Numerical keypad
Used to enter numerical values for various menu items in the channel or setup menus



Channel selectors
Change the active channel menu shown in the LCD display by pressing these buttons.

Channel output
Four shielded, standard BNC channel output signal connectors.

Channel current output indicators
A red LED indicates active pulse train generation.

Esc
Undo all changes to the menu items by pressing the escape key.

Setup
Enter the CS200 setup menu by pressing this button.

Single
Starts output of a single current pulse of the channel shown in the LCD display. When [**SYNCRON**] in the setup menu is set to [**YES**], all channels will start simultaneously, giving a single current pulse output.

Start
Start current stimulation using the stimulation protocol of the channel currently visible in the LCD display. When [**SYNCRON**] in the setup menu is set to [**YES**], all channels will start simultaneously.

Enter
Any changes of the values of menu items in the LCD display will be permanent after pressing the [**Enter**] key, until a new change is made.

Stop
Stop current stimulation of one or all channels.

Figure 2.1 *Current Stimulator - front panel*

2.2 Current Stimulator rear panel

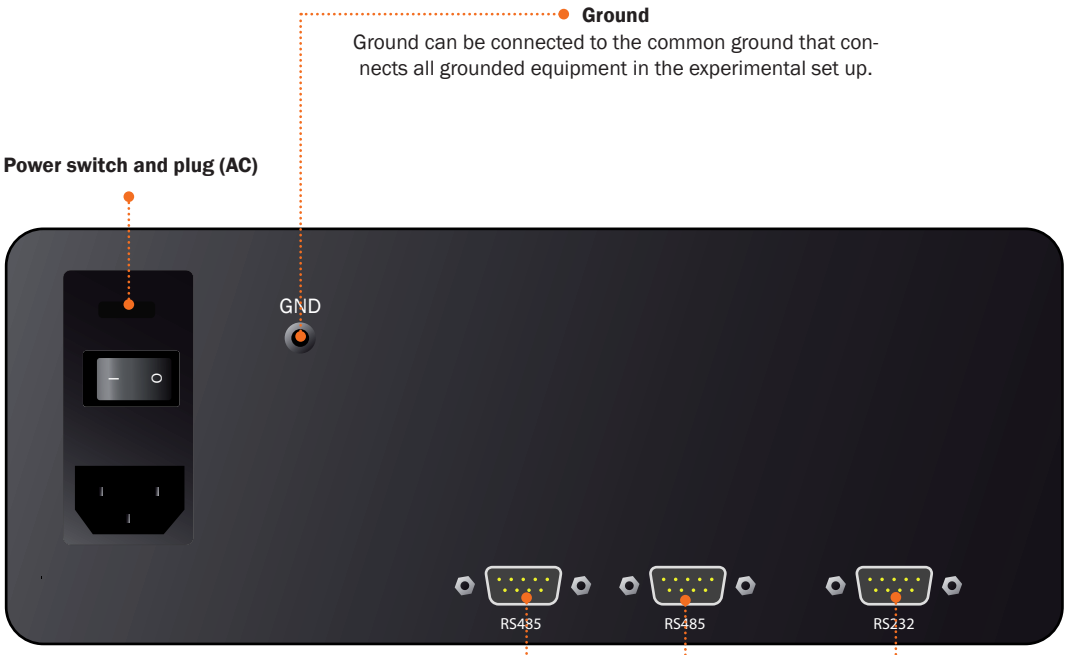


Figure 2.2 *Current Stimulator - rear panel*

2.3 Installation

2.3.1 Stand alone, manual control

- Use the supplied power cord for connecting the CS200 Current Stimulator to the power supply. Be sure that the power cord is compatible with your local power supply.
- Connect channel outputs to the electrodes of your experimental set up using a BNC connector. Typically platinum electrodes fit into an organ bath.

2.3.2 PC Controlled single device

A PC can control the function of the CS200 Current Stimulator. If only one serial device is connected to the PC serial port, the RS232 serial output situated on the backside of the Current Stimulator should be used

- Connect the R232 serial output to the PC serial port with a 9 pin (DB9) serial cable. Use a DB9 to DB25 converter if the PC serial output consists of a 25-pin, instead of a 9-pin socket.
- The CS200 operation can be controlled for example through the serial communication program 'HyperTerminal' (Windows®) using the commands explained in detail at next page.

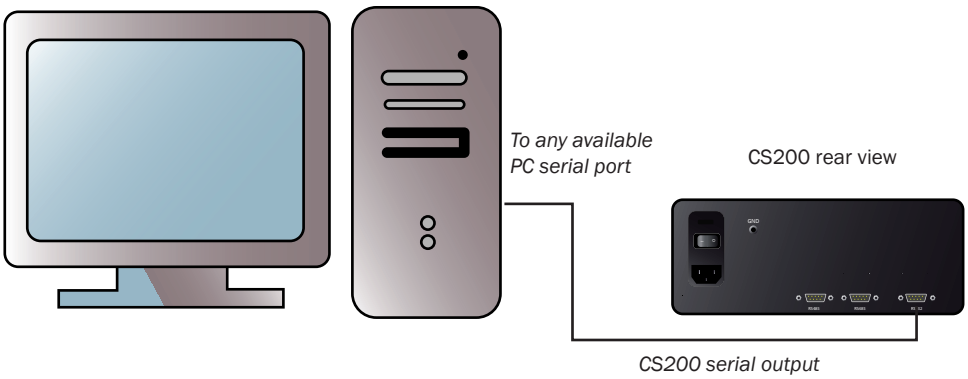


Figure 2.3 *PC control through RS232 serial connection*

CHAPTER 3 - USING THE CURRENT STIMULATOR

3.1 LCD display

- The LCD display is the user interface of the CS200, for manual control of the Current Stimulator.
- The first line of the display always indicates the menu item currently selected. Menu items can be divided into **channel menus** and **setup menus**.
- The second line is always the INPUT line. The input line is indicated by [**>**] instead of [**:**].
- The numerical key pad is used to enter new data at the input line. Following data entry [**Enter**] is pressed to store the new data entry at the input line.
- Pressing [**Esc**] can erase an erroneous data entry.
- All non-numerical menu items (e.g. Output: Mono or Bipolar) can be changed by pressing [**Enter**] until the desired change.
- Scroll through the menu displayed in the LCD display by pressing the up or down arrows, respectively.
- The LCD display reads [**ERROR**] on the entry line if entered data is outside the range indicated by the specifications of the CS200 Current Stimulator.
- Frequency and pulse duration that are not compatible with each other (e.g. frequency of 200 Hz and pulse duration of 10ms) will also results in a [**ERROR**] message in the entry line. Thus, there always has to be at least 1 ms between pulse duration and the reciprocal frequency (i.e. 1 / frequency).
- The first line of the LCD display will show blinking asterisks [******] indicating that a stimulation protocol has been started and is running.
- The display indicates [**--RESISTANCE TOO HIGH--**] if the electrical resistance at the electrodes is too high for the current that has been set in the stimulation protocol. Typically this occurs if electrodes are not immersed in physiological salt solution, i.e. if the Current Stimulator is started with the electrodes in air.

3.2 Channel menu

Every available channel has its own channel menu that can be accessed by pressing the appropriate channel selector on the front panel (see page 11). The channel number will be displayed in the first line of the LCD display. Every channel pulse protocol can be changed individually by pressing the respective channel selector and entering the appropriate values for the pulse and train parameters for that particular channel. Alternatively, all channel pulse and train parameters can be changed simultaneously if [**SYNCRON**] is set to [**YES**] in the Setup menu. In this case entering values for a parameter in the channel menu of CHANNEL 1 will also change the same parameter in all other channels available.

-- CHANNEL 1 --

Frequency	>	100 Hz
Pulse dur.	:	0.1 ms
Current	:	50 mA
Output	:	MONO
Train mode	:	CONT.
Train dur.	:	3 sec
Train dly.	:	180 sec
Start Freq.	:	0.5 Hz
Stop Freq.	:	64 Hz
Repeat dly.	:	120 sec

- [**Frequency**] defines the number of pulses per second (Hz).
- [**Pulse dur.**] Pulse duration defines the length of the pulse in msec.
- [**Current**] defines the amplitude of the pulse in milliampere.

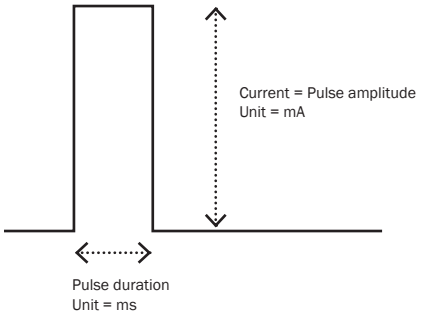


Figure 3.2 *Single current pulse*

- [**Output**] polarity is either MONO polar, meaning that current flows in one direction, or BIPOLAR meaning that current alternates in one and then the other direction.

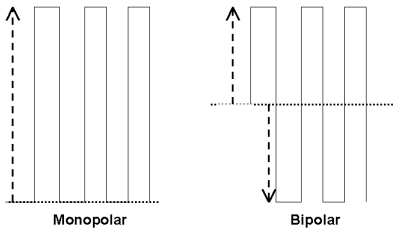


Figure 3.3 *Train mode*

- [**Train mode**] A pulse train consists of pulses with a frequency, pulse duration, current amplitude and polarity as defined in the menu-items described above. Three train modes can be entered which are described below.
  - [**OFF**]: The pulse stimulator runs continuously without interruption.
  - [**SINGLE**]: The pulse stimulator runs a single train of pulses defined by the menu items above [**Train**]
  - [**CONT.**]: The pulse stimulator runs pulse trains with the length and delay that are indicated in [**Train dur.**] and [**Train dly.**]
  - [**Freq. Step**]: The pulse stimulator runs a frequency ramp of pulse trains, starting with a frequency defined in [**Start freq.**] and doubling the frequency until the frequency defined in [**Stop freq.**] is reached, see figure 3.5 on next page.

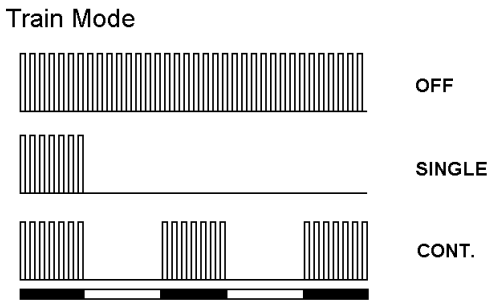


Figure 3.4

- [**Train dur.**] Train duration is entered in seconds. It indicates the length of the pulse train (see black bars below CONT. mode in fig. 3.4)
- [**Train dly.**] Train delay entered in seconds. This determines the interval between pulse trains (see white bars below CONT. Train mode in figure 3.4 above.
- [**Start freq.**] This menu item is only of relevance if [**Freq. step**] is chosen in [**Train mode**] otherwise this parameter is ignored. Start frequency defines the frequency at which the frequency ramp starts.
- [**Stop freq.**] Final step frequency of the frequency ramp.
- [**Repeat dly.**] Delay between frequency ramps in seconds. If this parameter is set to 0, the frequency ramp runs only once.

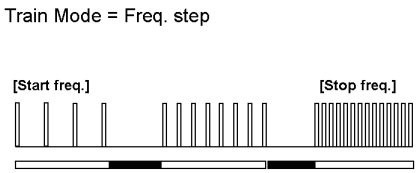
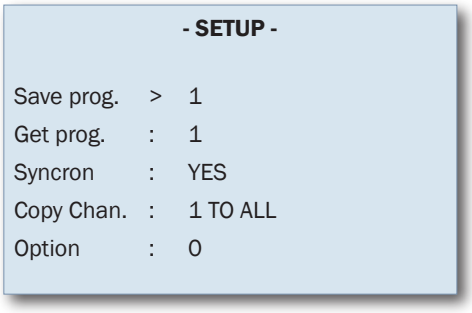


Figure 3.5 *Pulse trains with increasing frequencies. The length of the white bar below equals (Train dur.), the black (train delay)*

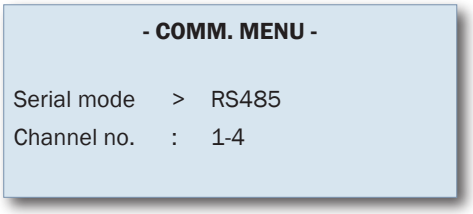
3.3 Setup menu



- [**Save prog.**] Up to 5 stimulation protocols, including all channel parameter information can be stored in an internal memory. Store the present channel programs by choosing a number between 1 and 5 and press [**Enter**].
- [**Get prog.**] By finding the appropriate program number (1 to 5) and pressing [**Enter**] one of the stimulation protocols that are stored in the memory can be retrieved.
- [**Syncron**] When this menu-item is enabled, by setting its value to [**YES**], pressing [**Start**] will result in simultaneous starting of all channels. When [**Syncron**] is set to [**NO**], pressing [**Start**] will only start the channel that is visible in the LCD display.
- [**Option**] contains service and communication submenus.

3.4 Communication submenu

To reach the communication submenu, press 7 [**Enter**] under options in the setup menu.



- [**Serial mode**] Here the RS232 or RS485 serial protocol is set. Using RS232, only 1 serial device, e.g. one current stimulator can be connected to one PC serial port (see “2.3.2 PC Controlled single device” on page 12), PC controlled single device). Choosing RS485 enables connecting multiple serial devices to a single PC serial port. To chose between RS232 and RS485 press [**Enter**]
- [**Channel no.**] This line is only visible if RS485 is chosen in the previous menu [Serial mode]. Channel numbers for the current stimulator are defined in this menu. Choose channel numbers for CS200: 1-4, 5-8, 9-12, 13-16 by pressing [**Enter**]. Thus 4 CS200 can be connected in series to one PC serial port together with four 610M/620M, 700MO/720MO and 800MS/820MS systems. The channel numbers that are entered in this menu will be visible at the first line of the channel menu.

3.5 Keyboard

- [**Start**] The Current Stimulator starts electrical stimulation by pressing the start key on the keypad. Depending on whether [**Syncron**] is set to [**Yes**] or [**No**], all channels will start simultaneously, or one channel, the channel currently active in the LCD display will start.
- [**STOP**] Ends current output from the active channel in the display, or ends current output from all channels if [**Syncron**] was set to [**Yes**].
- [**Single**] pressing this key will start only a single pulse of the active channel in the display with the pulse length defined in the channel menu. Again if [**Syncron**] in the setup menu was set to [**Yes**], a single pulse will start on all channels simultaneously.

CHAPTER 4 - SERIAL PROTOCOL FOR CS200

The CS200 Current Stimulator can be controlled remotely through a PC serial connection. Depending on whether the RS232 or RS485 serial protocol are chosen, either a single or multiple current stimulators connected in series can be controlled when connected to a single PC serial port (see “Figure 2.3 PC control through RS232 serial connection” on page 13). CS200 operation can be controlled for example through the serial communication program ‘HyperTerminal’ (Windows®) using the commands explained below.

4.1 PC serial port

The PC Serial port parameters should be set to the following values:

Bits per second = 9600
Data bits = 8
Parity = none
Stop bits = 0
Flow control = none

4.2 Serial addresses

The current stimulators receives the address range #80 - #90 with a possibility to connect four CS200 to the same PC serial port.

CS200	Channel 1-4	#80-#83 (single stimulator addresses
	Channel 5-8	#84-#87
	Channel 9-12	#88-#88B
	Channel 13-16	#8C-#8F

Table 1 *Channel addresses*

Version No.	#00	
Frequency	#01	
Pulse dur.	#02	
Current	#03	
Output	#04	
Train mode	#05	
Train dur.	#06	
Train dly.	#07	
Start freq.	#08	
Stop freq.	#09	
Repeat dly.	#10	
Start	#80	
Stop	#81	
Single	#82	
Syncron	#83	These three parameters
Save program	#84	only in combination
Get program	#85	with #80
Error status	#87	

Table 2 *internal addresses (non-hexadecimal)*

4.3 Address format

4.3.1 Requesting data

Command	=	aapp(cr)
Response	>	aa,pp,xxxx(cr)
For which:		
=	=	Request data
aa	=	Channel address (see Table 1)
pp	=	Internal address (see Table 2)
xxxx	=	Data returned from CS200 (length depending on data type)
(cr)	=	Carriage return

Example:

Command	?8003(cr)
Response	>80,03,0020(cr)

The value for [Current] on stimulator 1, channel 1 is requested.
Response is 20 mA.

Command	?8005(cr)
Response	>80,C(cr)

The status of Train mode is requested. The reply can be:

C for CONTINUE
O for OFF
S for SINGLE
F for FREQUENCY STEP

4.3.2 Setting data

Command	=	aappxxxx.x(cr)
Response	>	aa(cr)
For which:		
=	=	Set data
aa	=	Channel address (see Table 1)
pp	=	Internal address (see Table 2)
xxxx.x	=	New values for stimulator (length depending on data type)
(cr)	=	Carriage return

Example:

Command	=8003100(cr)
Response	>80(cr)

Current on channel 1 of stimulator 1 is set to 100 mA.
Data sent to the Current Stimulator will NOT be changed if they are outside the ranges of the respective stimulation parameters.

Command	=8005C(cr)
Response	>80(cr)

This command will set the train mode on channel 1 to CONTINUE.

Command	=8086C(cr)
Response	no response

4.3.3 Additional commands

Start Channel
1

Command =8080(cr)
Response >80(cr)

Stop Channel
1

Command =8081(cr)
Response >80(cr)

Check status of channel 1

Command ?8080(cr)
Response >80Y(cr) (channel 1 is On [Y = Yes]) or
>80N(cr) (channel 1 is Off [N = No])

Synchronize channels ([**Syncron**])

Command =8083Y(cr)
Response >80(cr)

Do NOT synchronize channels

Command =8083N(cr)
Response ><80(cr)

4.3.4 Saving and loading stored programs

Stimulation programs that are uploaded from a PC can be stored in, or retrieved from internal memory using the following command:

Command	=	aappx(cr)
Response	>	aa(cr)
For which:		
=	=	Set data
aa	=	Channel address (see Table 1)
pp	=	Internal address (see Table 2)
x	=	Program number
(cr)	=	Carriage return

Example:

Command =80841(cr)
Response >80(cr)

All channel parameters will be stored in program 1.

NOTE THAT BECAUSE STORING DATA TAKES ABOUT THREE SECONDS, THE RESPONSE WILL BE DELAYED ACCORDINGLY.

4.3.5 Error status

Any internal error in the stimulator can be retrieved with the following commands

Command	=	aappx(cr)
Response	>	aa(cr)
For which:		
=	=	Set data
aa	=	Channel address (see Table 1)
pp	=	Internal address (see Table 2)
xy	=	Error parameters
(cr)	=	o x = 0 : No timer errors
		o x = 1 : Internal timer communication error
		o x = 2 : Pulse duration too long or frequency to high
		o x = 3 : Pulse duration too long in FREQUENCY STEP MODE
		o y = 0 : No resistance error
		o y = 1 : Resistance in the chamber is too high
		= Carriage return

Example:

Command	=8087(cr)
Response	>8001(cr)

The electrical resistance between the electrodes is too high at channel 1.

APPENDIX 1 - SYSTEM SPECIFICATIONS

Pulse generator

Frequency:	0.1 - 256 Hz
Pulse duration:	0.03 - 500 msec
Current:	0 - 100 mA
Compliance:	50 Volts
Rise/fall time:	1.5 msec
Output:	Mono/Bipolar
Voltage:	100 to 240 VAC (auto) 50/60 HZ

Train generator

Mode 1:	Off
Mode 2:	Single
Mode 3:	Continuous
Mode 4:	Frequency step
Train duration:	0.1 - 3600 sec.
Train delay:	0.1 - 3600 sec.

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