C-Pace Navigator

Software Manual

C-Pace Navigator

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1 What is the C-Pace Navigator?

The C-Pace Navigator is a simple Windows program used to control the C-Pace family of culture stimulators by way of a USB connection. The C-Pace Navigator provides the user with a complete view of the current status of all banks and an easier method of programming the C-Pace than using the front panel interface.

Features

- Options and ranges are identical to the stand-alone device, so it is very easy to move back and forth between USB control and knob/display control.
- All banks and all settings can be viewed simultaneously.
- Bank settings can be saved to a file and reloaded onto the C-Pace.
- Banks can all be enabled or disabled in a single step.
- Complete bidirectional control of the device from either the computer or front panel.

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2 Manual Convention

Let us begin with definitions of stylistic conventions used in this manual.

- Underlined text refers to the names of interface elements shown in the illustrations included in most sections.
- *Italicized* text refers to names given to specific parts of the C-Pace Navigator interface like *scroll bar*.
- **Bold** text refers to mouse buttons or keystrokes that must be used in order to operate some function.
- The symbol § indicates the following name is a section in the manual.

A note icon indicates an important point that you should know.

An idea icon shows some ideas on how you can use a device or function.

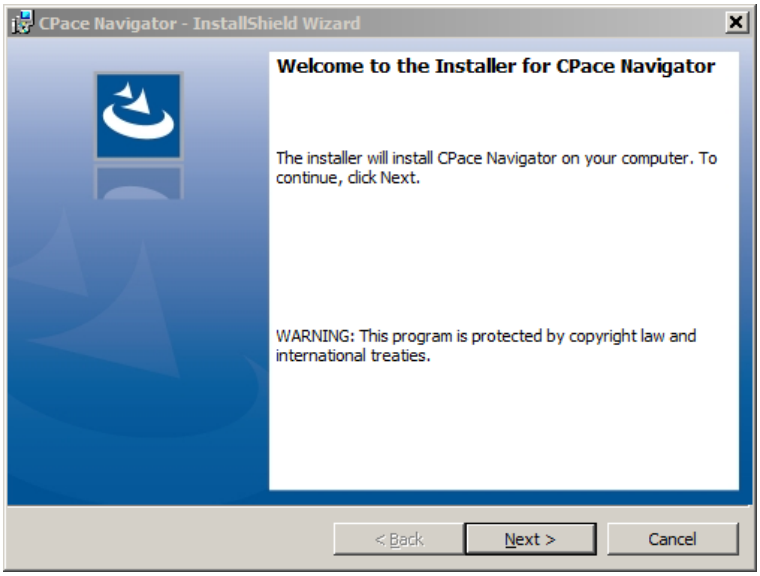
A stop icon indicates a potential for personal injury, equipment damage or data loss.

3 Installation and Setup

To use the C-Pace Navigator program, you must install the C-Pace Navigator software, install the hardware drivers, and then connect the C-Pace to the computer.

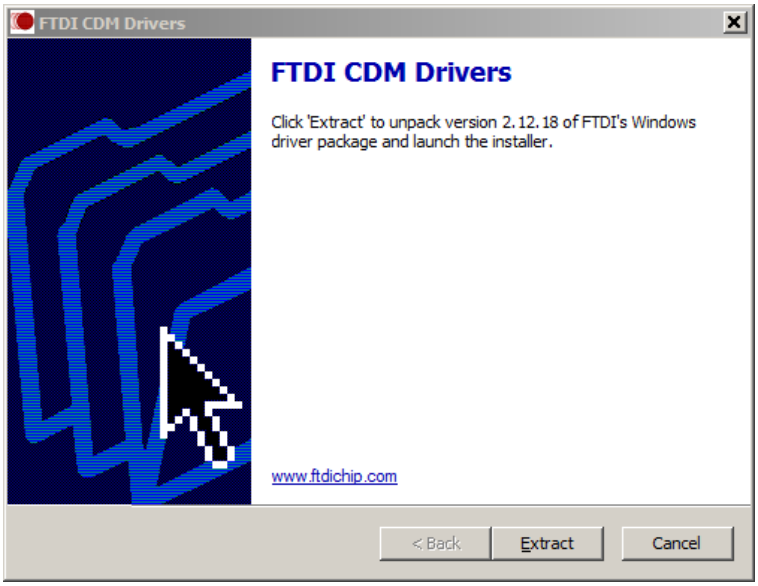
Install the Software and Drivers

To install the C-Pace Navigator, run the supplied setup program.



C-Pace Navigator Installer Start Window

Please note that you will need to install the hardware drivers as instructed at the end of the main installer as shown below.

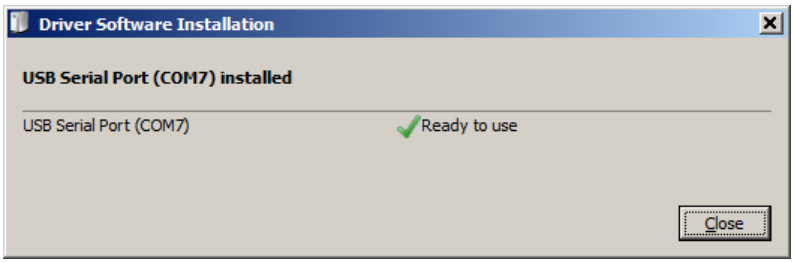


Driver Installation Window

Click the extract button and then follow the instructions to install the drivers.

Connect the C-Pace

When you connect the C-Pace to your computer, Windows should install the drivers automatically. It will appear as a Windows Serial Port.



Driver Installation Success Window

Once this completes, you are ready to go.

4 Overview

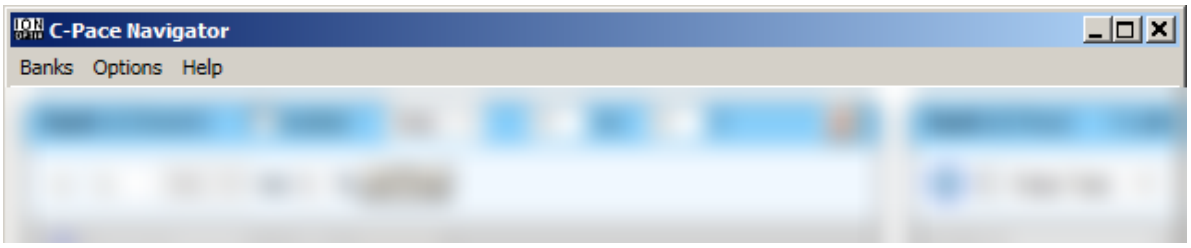
The C-Pace Navigator is a program that runs on your laptop or desktop computer and permits you to control a C-Pace culture stimulator. It works in parallel with the C-Pace box and the front panel interface. Any changes made via the front panel will appear in the Navigator and vice versa. The C-Pace Navigator does not introduce any new functionality to the C-Pace, thus everything you know from the C-Pace is applicable in the Navigator. The C-Pace Navigator has two primary interfaces: the main window and the menus.

Main Window

C-Pace Navigator Main Window

Above is an image of the C-Pace Navigator main window. This example shows four Bank Settings panels, one for each bank present in that particular C-Pace. The main window is the primary user interface for the C-Pace Navigator. It displays the current settings of each available bank. The blue section at the top of each bank panel contains the global bank settings that will likely only be set at the beginning of the experiment, such as voltage, duration and bank mode. The frequency or step related variables are shown in the gray section of each bank. Any variable may be adjusted at any time. The changes will be sent to the C-Pace by pressing enter, tab or by selecting another field. All these settings are explained in detail in § Bank Settings 8.

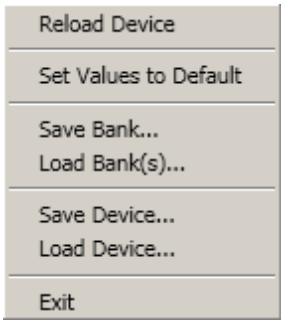
Menu Bar



C-Pace Navigator Menu Bar

The second main Navigator interface is the *menu bar*, shown above. There are three *menus*, Banks, Options and Help. The sections below give an overview of each menu.

Banks Menu

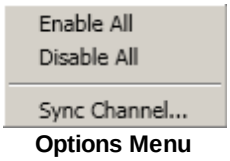


Banks Menu

The Banks *menu* primarily provides access to functions that load and save device settings en masse, either to files on the computer or to factory defaults.

Reload Device	Re-synchronize the C-Pace Navigator with the device. This is useful if you have rebooted the device without exiting the program.
Set Values to Default	Restore all banks to factory defaults. This is the same as selecting the Re-Initialize function from the mode menu of every bank.
Save Bank...	Save settings for a single bank. See § Save Single Bank 20.
Load Bank(s)...	Load settings from a single bank file into one or more banks. See § Load Single Bank 21.
Save Device...	Save settings for the entire device. See § Save Device 22.
Load Device...	Load settings for the entire device. See § Load Device 23.
Exit	Exit the C-Pace Navigator Program.

Options Menu



Options Menu

The Options *menu* primarily provides access to device level functions that operate collectively on multiple banks or which effect the behavior of the device overall.

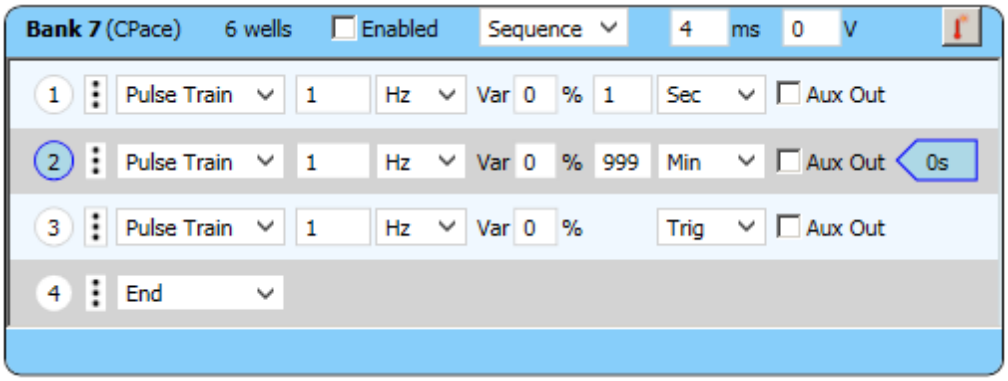
Enable All	Enables all banks.
Disable All	Disables all banks.
Sync Channel...	Set the channel for external synchronization. See § Sync Channel Selection 24.

Help Menu

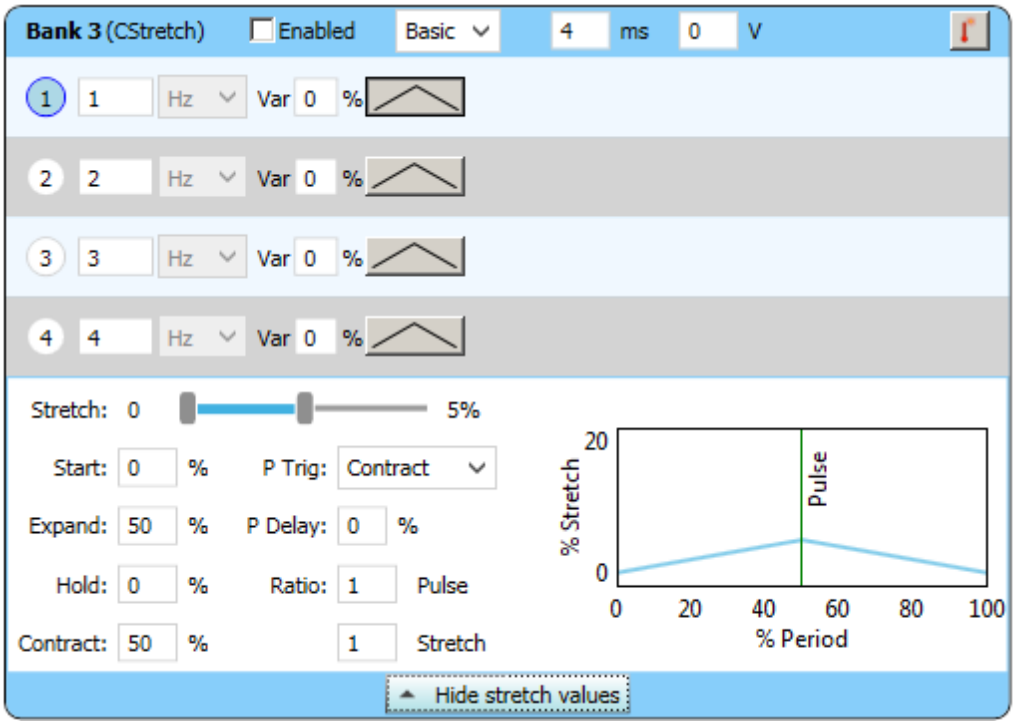
Help Menu

The Help *menu* provides access to the online version of this manual.

5 Bank Settings



C-Dish Bank Settings Panel



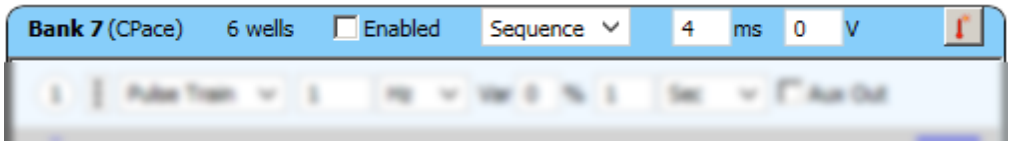
C-Stretch Bank Settings Panel

The images above show the Bank Settings panel for a single bank. The top image shows the panel for a C-Dish bank while the bottom image shows the panel for a C-Stretch bank.

C-Dish refers to any of our multi-well culture dish electrode assemblies that permit chronic pacing of cells in culture. C-Stretch refers to our 6 well combined mechanical stretch and electrical stimulation device.

In both cases the panel has the Global Bank Settings 9 at the top and the Mode Settings 11 immediately below. If the panel is for a C-Stretch bank there is a third area below the Mode Settings for the C-Stretch Settings 15. The sections below explain each of these areas in detail.

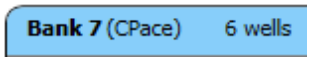
5.1 Global Bank Settings



Global Bank Settings

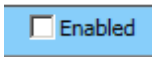
The top section of every Bank Settings panel shows the global settings. These settings apply across all presets or sequence steps in the lower section. Each of these settings is explained below.

Bank Description



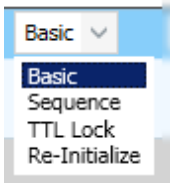
Shows which physical slot the bank resides in, what kind of device is attached to the bank, C-Stretch or C-Dish, and if a C-Dish, the well count.

Enabled



When the Enabled *checkbox* is checked, the C-Pace will output its stimuli. When a bank is disabled, reed-relays in the high voltage path are opened, ensuring a completely open circuit. These relays are also opened between pulses. Banks may be enabled or disabled simultaneously through the Options *menu*.

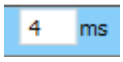
Mode Selection



There are four available modes that can be selected from this drop down list: Basic 12, Sequence 13, TTL Lock 15 and Re-initialize. The mode that is selected will determine the choices that are available in the adjoining gray section. See § Mode Settings 11 for more information on the effects of mode choice.

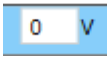
Re-initialize is a pseudo-mode that just sets the bank back to basic mode and does not otherwise add any functionality.

Duration



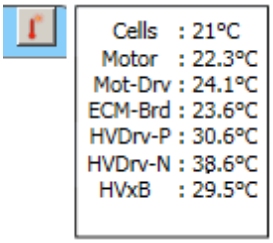
The duration of each pulse can be adjusted between 0.4 and 10 ms in 0.2 ms increments. To reduce electrolysis byproducts, the pulses that are emitted are all square bipolar pulses, so half of the chosen duration will be positive, half negative. To further reduce byproducts, the duration should be kept as short as possible. Standard values are in the 4-10 ms range. The upper range of the duration varies with current frequency, variability settings, and number of wells.

Voltage



This adjusts the voltage of each pulse from 0.0 - 40.0 V in 0.1 V increments. It is worth experimenting with the voltage setting. Many labs find they get best end results by selecting a voltage which initially has a relatively low percent capture (50% or so) following the theory that this method pre-selects the healthiest cells and avoids the damage to them caused by excessive voltage. The different configurations of the C-Dishes will need different voltages. For myocytes, the four well dishes will need voltages in the 32-40 V range, the 35 mm discrete dishes about 8-10 V, the 6 well dishes about 10-14 V and the 8 well dishes about 16-20 V. Watching the cells with a microscope is the best way to select the appropriate voltage for your cells.

Temperature

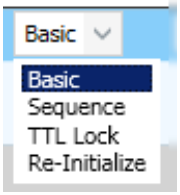


Clicking on the Temperature button displays the bank temperature window shown to the left. This example shows the window you will get when attached to a C-Stretch device. The listed values are:

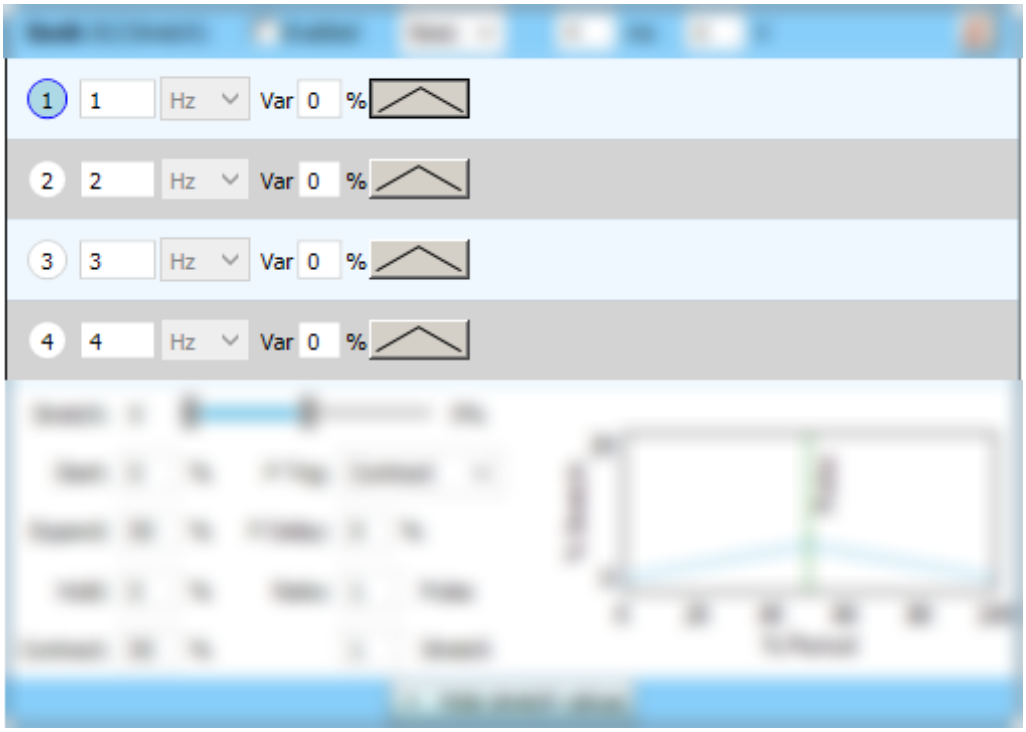
- Cells: The temperature in the cell chamber.
- Motor: The temperature of the motor that is driving the stretch protocols.
- Mot-Drv: The temperature of the motor driver.
- ECM-Brd: The temperature of the interface board in the motor chamber.
- HVDrv-P: The temperature of the positive, high voltage, high current drive transistor on the high-voltage bank (HVxB) board.
- HVDrv-N: The temperature of the negative, high voltage, high current voltage drive transistor on the HVxB board.
- HVxB: The temperature of the area near the HVxB.

If the bank is attached to a C-Dish, only the last three values will be listed. With the exception of the Cells parameter, these are informational values useful for debugging purposes.

5.2 Mode Settings



Mode Selection Menu



Mode Settings Area

These figures show the Mode Selection *menu*, described earlier, and the Mode Settings area of the Bank Settings panel. When you select any of the real modes (Basic 12, Sequence 13, TTL Lock 15) the controls in the Mode Settings area will change as described in the sections below.

The Re-initialize pseudo-mode actually just sets the bank back to basic mode and does not otherwise add any functionality.

5.2.1 Pacing Events

Before diving into the Mode Settings for the C-Pace Navigator, we would like to introduce the idea of a Pacing Event. Since C-Pace devices can impart electrical pulses and mechanical stretch onto the cells (in combination or singly), the term "pacing frequency" or "stimulation frequency" becomes somewhat confusing as they are both electrical-pulse-based terminology. We choose Pacing Event, or simply Event, as a neutral term divorced from electrical or stretch inspired terminology.

Each Event is an internally generated signal that subsequently triggers (possibly with a delay) the desired electrical pulse or stretch waveform. There are two parameters that dictate the generation of Pacing Events: the Event Frequency and the Event Variability.

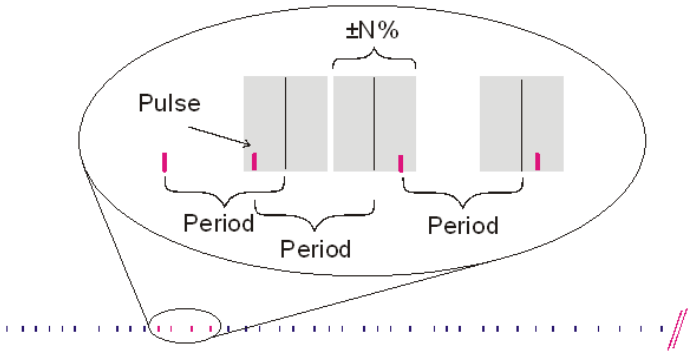
Event Frequency

When you program a frequency for either a Basic Mode Preset or a Sequence step, you are programming the Event Frequency. The range of frequencies available depends on the attached device as shown in the table below.

Bank Configuration	Frequency Range
C-Dish	1 Hz to 99 Hz
C-Stretch	1 Hz to 10 Hz

Event Variability

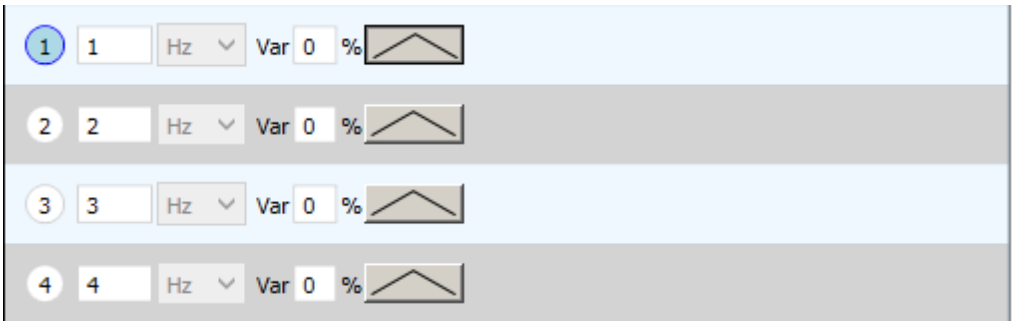
The variability parameter is used to generate irregular beats. For most purposes, this should be set to 00% which means no variability.



When enabled, the Event Variability introduces a pseudo-random variation into the Event Frequency. This variation is specified as a percentage of the time between Events as dictated by the Event Frequency (i.e. the period) and guarantees an average effective rate over 100 pulses. For example, if a frequency of 1 Hz with 50% variability is selected, 100 pulses will have occurred after 100 seconds, but the period between any two pulses can be anything from 500 ms to 1500 ms. In actuality, the basis for the variability is a list of numbers from 1 to 100 that were randomly shuffled and saved. Therefore, the pulse train will repeat every 100 pulses, and the same settings will always produce the same pulse train.

The maximum allowed percentage is determined by pulse duration, number of channels, and the frequency setting.

5.2.2 Basic Mode



Basic Mode Settings

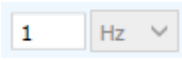
The image above shows the Basic Mode Settings area of the Bank Settings panel. Basic mode is used to continuously output one set of event stimuli parameters until the user manually makes a change.

Four different parameter sets, called presets, can be programmed and stored and then easily switched between. The sections below explain each.

Preset Numbers/Active Preset

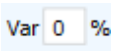
The circular *button* at the beginning of each row shows the preset number. The blue-filled *button* indicates the active preset and will be the preset that will run when the bank is activated. Clicking in an inactive preset *button* will activate that preset immediately.

Frequency



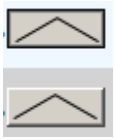
The event frequency for the preset is dictated by the frequency controls. For basic mode the event frequency can only be specified in Hertz. See § Pacer Event Frequency 11 for more information.

Variability



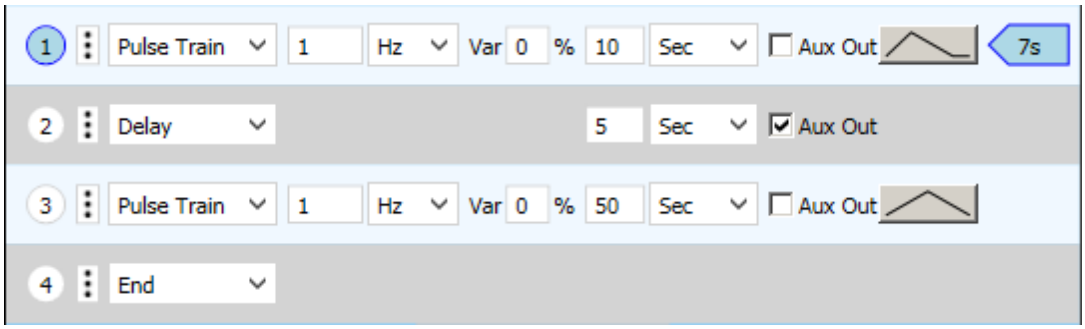
This edit field specifies the variability of the event frequency for the preset. See § Pacer Event Variability 12 for more information on variability.

Stretch Parameters Button



If a C-Stretch is attached to this bank, the Stretch Parameters *toggle button* will be visible. The graph on the *toggle button* shows a representation of the stretch profile. Clicking on the Stretch Parameters *toggle button* toggles the visibility of the Stretch Parameters area. The top *button* in the figure at left is in the "pressed" state and indicates that the Stretch Parameters area is visible. Only one Stretch Parameters *toggle button* can be pressed at a time and indicates the preset whose parameters are being edited.

5.2.3 Sequence Mode



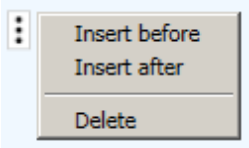
Sequence Mode Settings

Sequence mode offers the user the ability to program multi-step protocols of up to 5 steps. Each row in the Mode Settings area of the Bank Panel, shown above, is a single step. Each step can be either a delay or a pulse train. The step ends after either a trigger or a specified number of seconds, minutes or pulses have elapsed, and then the next step immediately begins. At the end of last step, the protocol will immediately loop back to the beginning. Sequence mode also offers control of the TTL output Aux Out.

Step Numbers

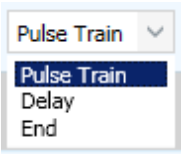
The circular *button* at the beginning of each row shows the sequence step number. The blue-filled button indicates the active step. Clicking on an inactive step *button* will cause the sequence to immediately jump to that step.

Step Menu



The Step *menu* appears if you click the small *button* with three dots and allows you to insert steps above or below the given step or to delete the given step.

Step Type



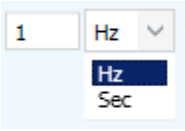
The Step Type *combo-box* has three options:

Pulse Train - the step will generate pacer events which will generate electrical pulses and/or mechanical stretches as appropriate.

Delay - the step will suspend all stimuli for the duration of the step.

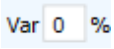
End - the step does nothing and indicates the last step in the sequence. Setting a step to End deletes all steps after it. Changing a step from End to Pulse Train or Delay adds a step to the step table.

Frequency/Period



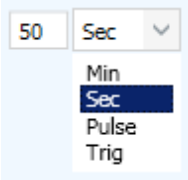
The event frequency for the step is dictated by the frequency controls. For Sequence Mode the event frequency can be specified in Hertz or seconds. This permits easy specification of very long intervals. See § Pacer Event Frequency 11 for more information.

Variability



This edit field specifies the variability of the event frequency for the preset. See § Pacer Event Variability 12 for more information on variability.

Termination Condition



The termination condition determines how the step ends. There are 4 options:

Min - The step ends after the indicated number of minutes.

Sec - The step ends after the indicated number of seconds.

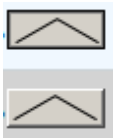
Pulse - The step ends after the indicated number of event pulses have occurred.

Trig - The step ends when it sees a digital signal on the C-Pace Advance input.

Aux Out

If this box is checked and the bank is selected in the "Digital Outputs" section of the "Options" *menu*, a positive TTL pulse will be sent to the Aux Out BNC. In the case of a Pulse Train step, the pulse will coincide with the first pulse of the step. In the case of a Delay step, the line will be brought high for the full extent of the delay.

Stretch Parameters Button

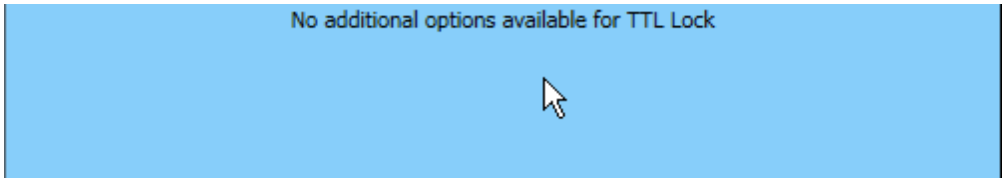


If a C-Stretch is attached to this bank, the Stretch Parameters *toggle button* will be visible. The graph on the *toggle button* shows a representation of the stretch profile. Clicking on the Stretch Parameters *toggle button* toggles the visibility state of the Stretch Parameters area. The top *button* in the figure at left is in the "pressed" state and indicates that the Stretch Parameters area is visible. Only one Stretch Parameters *toggle button* can be pressed at a time and indicates the step whose parameters are being edited.

Step Countdown

This arrow will appear to the right of the currently running step and will provide a countdown indicating how much time or how many pulses remain before the step ends.

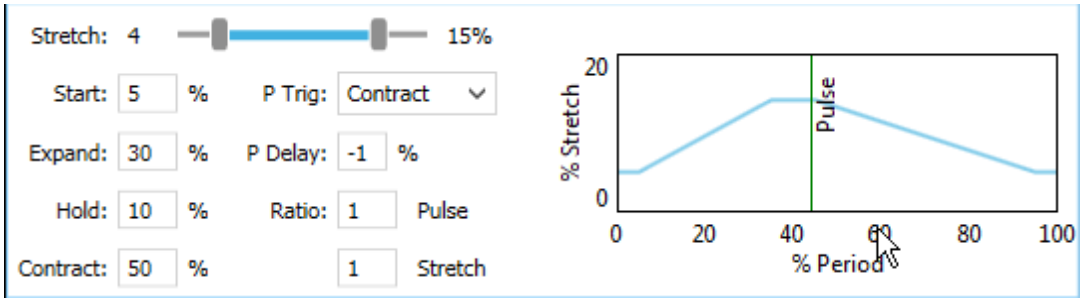
5.2.4 TTL Lock Mode



TTL Lock Mode Settings

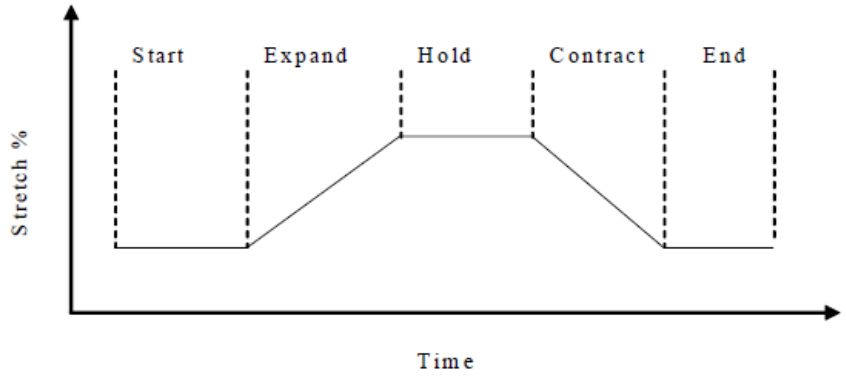
In this mode, a rising edge on the digital signal at the Pulse In BNC input on the C-Pace unit is itself the pacer event and will cause the electrical stimulus to fire. Since all frequency control is external to the C-Pace, there are no available frequency settings. This mode is not available for C-Stretch banks.

5.3 Stretch Settings



Stretch Settings Area

Above is a figure showing the stretch parameters for a given Basic Mode Preset or Sequence Mode Step. These parameters allow you to configure all aspects of the stretch motion itself and also the temporal relationship of the stretch to the electrical stimulus. The stretch waveform itself is illustrated by the figure below and consists of 5 phases on the time axis: Start, Expand, Hold, Contract and End.



The 5 Phases of the Stretch Waveform

This figure is also shown in schematic form in the right hand side of the Stretch Settings area. Both the maximum and minimum percent stretch values and the durations of each of the 5 phases of the profile are programmable by the user.

Stretch

The Preload (the least amount of stretch) and the Load (the largest amount of stretch) of the stretch protocol are set via the controls shown at the left. The units are in % stretch. You can adjust either end (i.e the Preload or Load) or you can slide the whole blue line which keeps the stretch amount the same while changing the initial Preload amount. These values will be limited such that for a given frequency and expand and contract times, the maximum motor velocity is not exceeded.

The Preload and Load stretch amounts dictate the amount that the vertical posts that hold the flexible dishes move. For larger stretch amounts, the dish itself will stretch which results in the cells stretching less than the indicated amount.

Start

Start: 5 %

This field determines the length of the Start phase. The units are in % event frequency. That means that if you have set your event frequency to 1 Hz, a 5% start phase will be 50 ms long. This value is limited by the fact that the total duration of all phases cannot exceed 100%.

Expand

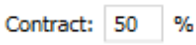
Expand: 30 %

This field determines the length of the Expand phase. The units are in % event frequency. That means that if you have set your event frequency to 1 Hz, a 5% expand phase will be 50 ms long. This value is limited in by the fact that the total duration of all phases cannot exceed 100%. It is also limited by the speed of the motor. The smaller this value, the faster the motor must move for a given stretch distance such that the Expand phase duration will eventually be bound by the maximum motor speed.

Hold

This field determines the length of the Hold phase. The units are in % event frequency. That means that if you have set your event frequency to 1 Hz, a 5% Hold phase will be 50 ms long. This value is limited by the fact that the total duration of all phases cannot exceed 100%.

Contract



This field determines the length of the Contract phase. The units are in % event frequency. That means that if you have set your event frequency to 1 Hz, a 5% Contract phase will be 50 ms long. This value is limited in by the fact that the total duration of all phases cannot exceed 100%. It is also limited by the speed of the motor. The smaller this value, the faster the motor must move for a given stretch distance such that the Contract phase duration will eventually be bound by the maximum motor speed.

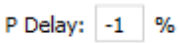
End

The user does not have direct control over the duration of the End phase. This value is simply the remainder of the 100% total after the other four phases have been totaled. Thus while the segment is shown in the schematic graph, there is no numeric printout anywhere in the user interface.

P Trig

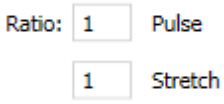
The P Trig setting determines which stretch phase triggers the electrical pulse. The beginning of the selected stretch phase will be the trigger for the electrical pulse. The electrical pulse can be delayed from the trigger by using the P Delay setting.

P Delay



The P Delay setting is an offset which is added to the time of the P Trig setting to create the actual time of the electrical stimulus pulse. The units are in % event frequency. For example, if P Trig is set to the Contract phase and P Delay is -1% and the event frequency is 1 Hz, the electrical pulse will fire 10ms *before* the start of the Contract phase. If the value were +1%, it would fire 10 ms after the start of the Contract phase.

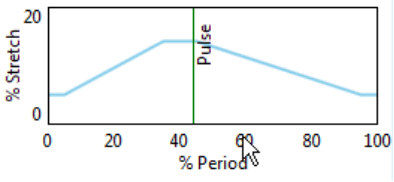
Ratio



The Ratio ratio setting determines how many electrical pulses occur relative to the number of stretch waveforms. For example a 2:1 ratio indicates that for every pacer event you will get an electrical pulse and every other event you will get a stretch waveform. Below are other examples.

Pulse	Stretch	Result
1	1	Pulse and stretch every event
2	2	Pulse and stretch every event
0	X	Only stretches.
X	0	Only pulses.
3	1	Pulse every event, stretch every 3rd event.
3	2	Pulse every event, skipped stretch every 3rd event.
2	3	Stretch every event, pulse skipped every 3rd event.

Schematic Graph



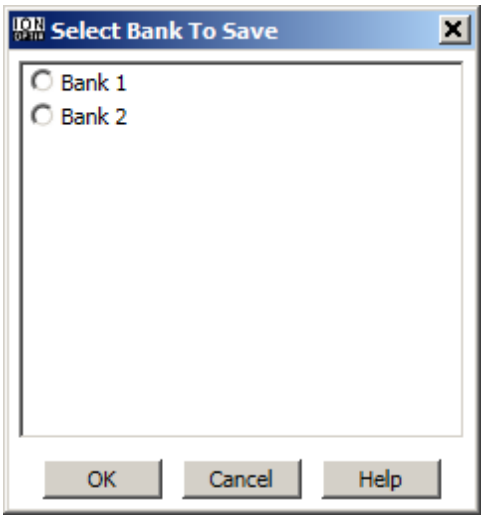
The graph at the right of the Stretch Settings area shows the current stretch waveform and the location of the electrical stimulation pulse given the current settings. It will automatically update as the other parameters are adjusted.

6 Bank Load/Save

The most substantial benefit of the computer interface is the ability to save and load files. Files may be created to save either the settings of an individual bank or of all banks on the device. At a later date, these files can be loaded back onto the device to ensure that an experimental protocol has been exactly replicated and to eliminate the need to reprogram each step of a long protocol. The enable status is not saved as part of the file.

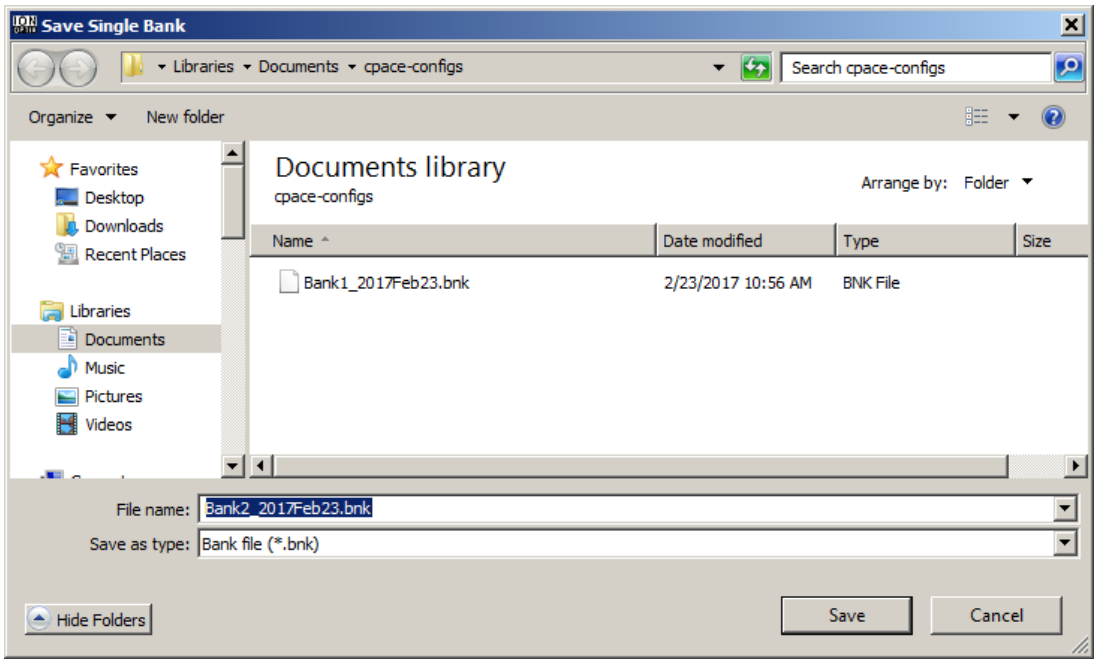
6.1 Save Single Bank

The Save Bank... *menu item* from the Banks *menu* lets you save the settings for a single bank to a file . This first brings up the Select Bank To Save *dialog box* shown below.



Select Bank To Save Dialog Box

Here you choose the bank you wish to save. If you click OK, to proceed the Save Single Bank *dialog box* shown below will appear. Clicking Cancel will stop the whole operation.

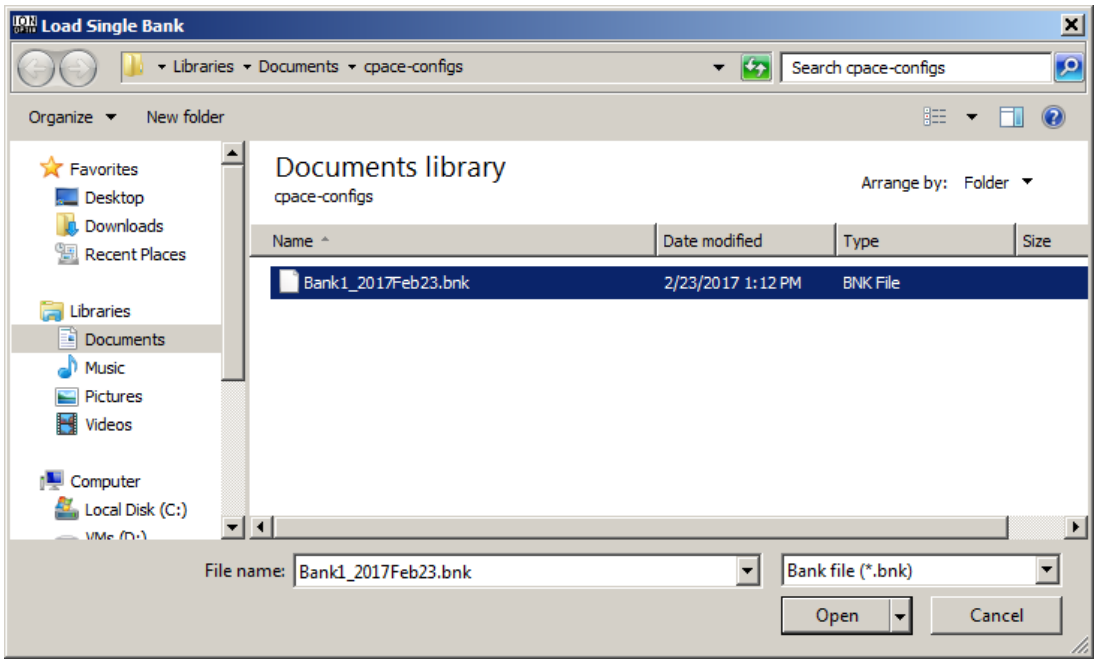


Save Single Bank Dialog Box

The Save Single Bank *dialog box* lets you navigate to the appropriate folder and select the filename for the BNK file that will hold the bank configuration data.

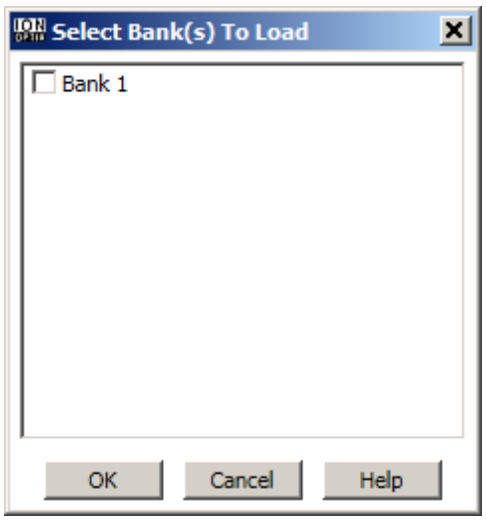
6.2 Load Single Bank

The Load Bank... *menu item* from the Banks *menu* lets you load settings from a previously saved BNK file into one or more banks. First you will see the Load Single Bank *dialog box* below.



Load Single Bank Dialog Box

This lets you select the BNK file you wish to load. Clicking the OK button will bring up the Select Bank(s) To Load *dialog box* shown below, while clicking Cancel will stop the whole operation.

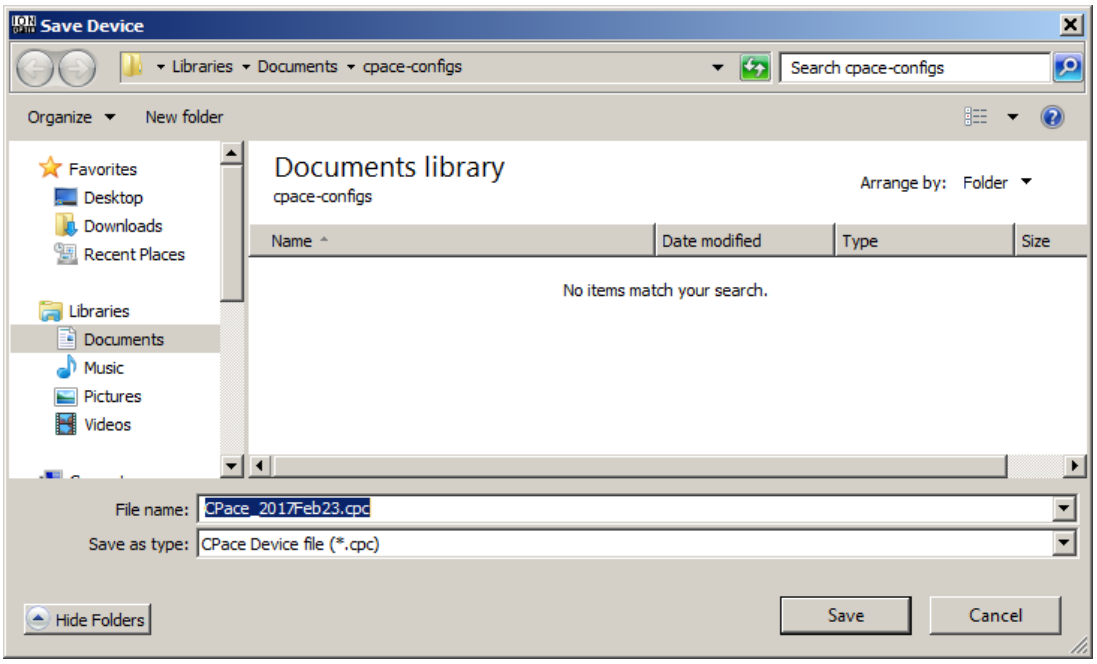


Select Bank(s) To Load Dialog Box

The Select Bank(s) To Load *dialog box*, lets you select the banks that will be loaded with the saved parameters. The C-Pace Navigator will only offer to load banks where the bank type (i.e. C-Stretch, 4 Well C-Dish, 12 Well C-Dish, etc) match those of the saved bank. This feature makes it possible to quickly make groups of banks have the same parameter sets.

6.3 Save Device

The Save Device... *menu item* from the Banks *menu* lets you save the configurations of all banks in the C-Pace at once via the the Save Device *dialog box* shown below.

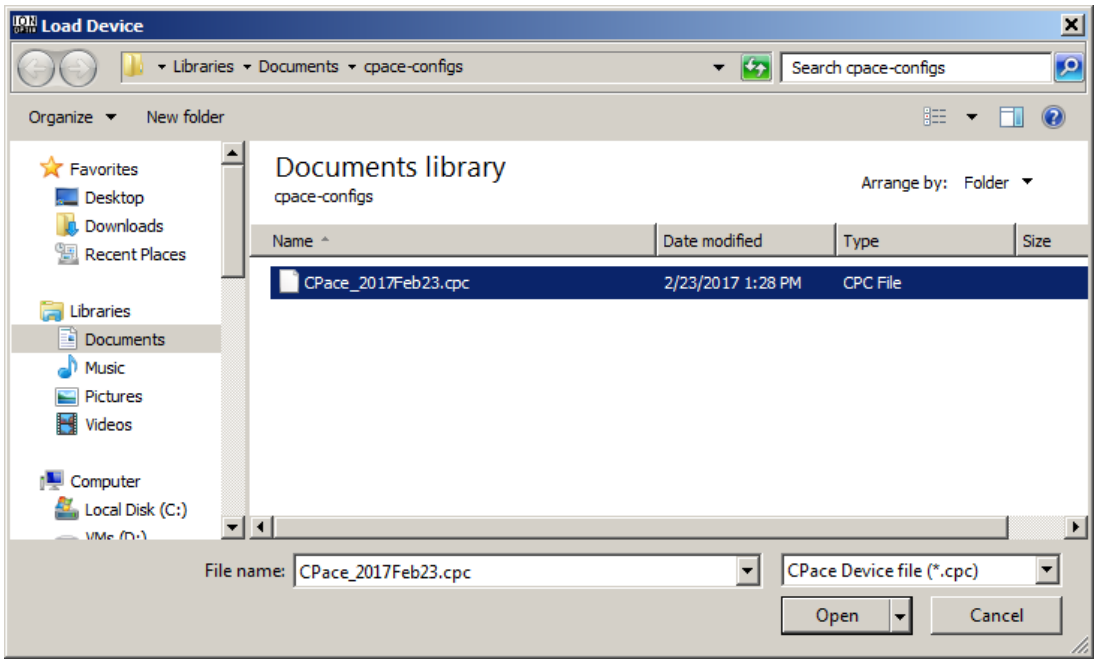


Save Device Dialog Box

This *dialog box* lets you can navigate to the appropriate folder and select the filename for the CPC file that will hold the C-Pace configuration data.

6.4 Load Device

The Load Device... *menu item* from the Banks *menu* lets you load settings from a previously saved CPC file into the C-Pace via the Load Device *dialog box* shown below.

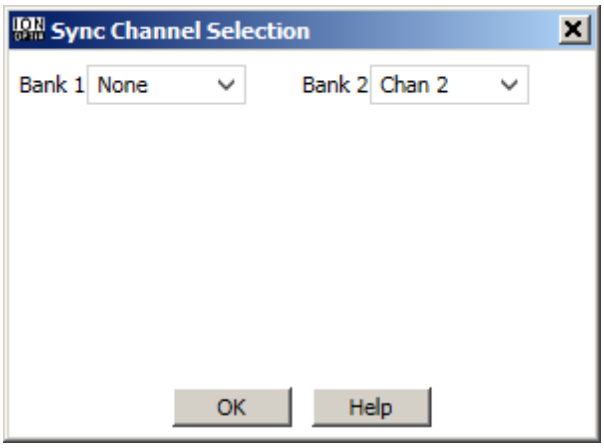


Load Device Dialog Box

Here you can select the CPC file you wish to load. Clicking OK, will load the saved settings into all banks but only if the current bank type (i.e. C-Stretch, 4-Well C-Dish, 12-Well C-Dish, etc) matches that of the bank when the file was saved. Clicking Cancel will stop the whole operation.

7 Sync Channel Selection

The C-Pace has two digital (TTL level) outputs for synchronizing other devices to the C-Pace: Gate Out and Aux Out. Gate Out emits a TTL pulse for every stimulus pulse. Aux Out is only used in Sequence Mode 13. In both cases, the actual TTL pulse is synchronized to the stimulus pulse associated with a specific stimulus channel (typically a single well of a C-Dish), called the Sync Channel. That channel is selected via the Sync Channel Selection *dialog box* shown below.



Sync Channel Select Dialog Box

Select the channel from the bank you want to be used as the Sync Channel. The *dialog box* enforces the following rule: there must be exactly one channel on one bank selected as Sync Channel.

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