Heliophor® Light Engine

User's Manual

This manual contains important information for the safe and efficient operation of the Heliophor Light Engine. Please read the manual in its entirety before operating the light source and heed all safety warnings.

The 89 North® Heliophor® light source system is designed and tested in accordance with IEC 61010-1:2010, CAN/CSA C22.2 Number 61010-1, CENELEC EN 61326-1:2006, and FCC Part 15 Subpart B, Class B.

Prior to installation, carefully inspect all components for any signs of damage that may have occurred during shipping. If any damage is suspected, contact 89 North or your authorized distributor immediately.

WARNING: **Carefully read and follow all safety precautions!**

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I. SAFETY INFORMATION

Please read and follow all safety instructions **BEFORE** installing or operating your new Heliophor. Failure to comply with the safety instructions may result in fire, electrical shock, injury, or damage to equipment.

WARNING:

The Heliophor produces intense illumination. Do not stare into the output of the liquid light guide. The microscope end of the liquid light guide has no safety interlock; it must not be directed at anything sensitive to light, including human eyes. The greatest danger is temporary impairment of vision; however, the 405 module emits near-UV light that could cause permanent damage with repeated exposure.

To test the system, shine the microscope end of the liquid light guide onto a white surface and view the resultant reflection. Take special care with the 405 module, which may not appear bright to the human eye, but can cause permanent damage.

Do not place liquid on the unit or accessories. Damage to sensitive internal components may result.

Do not drop the unit or accessories. Damage to sensitive internal components may result.

Follow recommendations for air flow clearance. The system may overheat without adequate air flow. Allow extra clearance if any other heat-producing elements are located nearby.

Only modules, lenses, dichroics, filters, and liquid light guides supplied by the manufacturer shall be used with the Heliophor. The use of other products may prevent the proper operation of the user-protections included on the equipment.

Only utilize power cords supplied by 89 North.

II. INTRODUCTION

A. INTENDED USE

The Heliophor is a pumped-phosphor light engine system specifically designed for fluorescence imaging. It may contain up to 6 user-exchangeable modules and their associated optics. Only modules and optics supplied by 89 North should be used in the system. Unapproved lenses, filters, and dichroics can damage the unit and will void the system warranty.

The Heliophor's illumination is directed to an imaging system via a liquid light guide (LLG). The LLG provides flexibility in the placement of the main body of the light source. The Heliophor supports both 3mm and 5mm core diameter LLGs. Only light guides provided by 89 North should be used with the Heliophor. Use of other light guides may damage the system and will void the warranty.

Because of its intense brightness, the Heliophor includes several safety interlocks that, when tripped, will block the light that is produced by the system. Do not override these interlocks. Doing so may result in injury to the user and/or the unit and will immediately void the warranty.

B. SPECIFICATIONS

Table 1 - Specifications

Dimensions	18”x18.5”X8”
Required Clearance	15 cm/ 6 in around all sides of the main unit *
Weight	35.5 lbs (with no modules)
Operating Temperature	10-25 deg C/ 50-75 deg F
Operating Humidity	30-75% relative humidity, non-condensing
Input Power Requirements	100-120V AC or 200-240V AC, 50-60 Hz Minimum of 10 amps
Fuses	No user changeable fuses
Host computer communication	Virtual COM over USB
Number of modules that can be on simultaneously	4

* Clearance requirements apply only to locations with no other heat sources (i.e., no nearby equipment that produces heat, such as CPUs, other light sources, etc.).

III. PACKAGE CONTENTS

- Heliophor main unit (light engine chassis)
- Hand controller
- Modules contained in system w/ associated dichroic (specified on enclosed configuration sheet)
- Module blanks (5 in total)
- 2 mirror mounts (may be installed in system depending on the number of modules ordered)
- USB cable
- Power cable
- Software CD
- Liquid light guide (LLG)
- Tool kit – flathead screwdriver, Phillips head screwdriver, 9/64” hex key
- Return shipping label (US only)

Optional components

- Additional modules and their associated dichroics (specified on enclosed configuration sheet)
- Additional liquid light guide
- Microscope adapter(s)
- DB-25 cable
- Full break-out box

IV. SET UP AND INSTALLATION

A. INSTALLATION REQUIREMENTS

The Heliophor requires input power of 100-120V AC or 200-240V AC, 50-60 Hz.

A PC running Windows XP or later (32-bit or 64-bit) is required to run the HELIOPHOR SOFTWARE. A virtual COM port must be installed (detailed below).

Ensure that 6" (15 cm) of clearance is available on all sides of the unit. Note that the clearance between the Heliophor and other pieces of heat-producing equipment should be increased to ensure that the heat from one unit does not contaminate the required cool air stream for the other.

Within the US, please utilize the enclosed return shipping label to return packaging to 89 North. We will happily reuse and recycle the packaging components for you.

B. SOFTWARE INSTALLATION

PC control of the Heliophor requires the installation of the Heliophor device drivers onto the host PC. Software is included on the enclosed CD. To install the drivers, run *Heliophor.msi* or *Heliophor.x64.msi* (for 32-bit and 64-bit machines respectively) and follow the instructions on the screen.

Installing the Heliophor Device Drivers

Connect the Heliophor to the host computer via the supplied USB cable. Turn on the Heliophor. Windows should automatically install the required drivers from the driver that was registered above (Software Installation).

If the driver installation fails, open the device manager and right click on the driver in the "Other Devices" section with the yellow "!" called "89 North Virtual Com" and select "Update Driver". In the "How do you want to search for driver software" screen, click "Browse my computer for driver software".

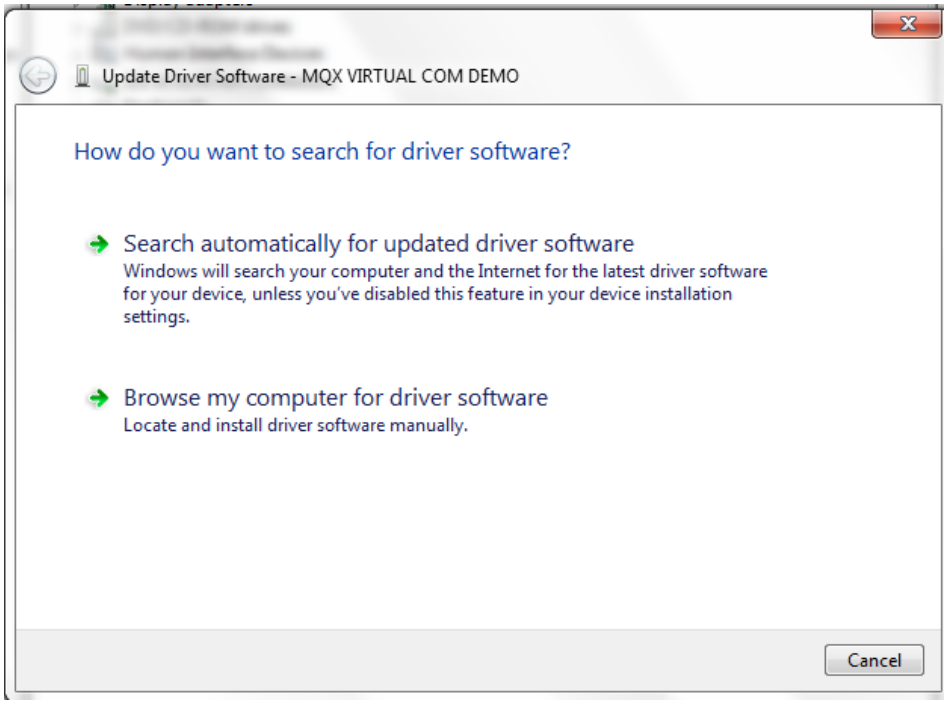


Figure 1 - Update Driver Software Screen

A window will open that allows you to browse for the driver software. Click “Browse” and select C:\Program Files\89North\Heliophor\” and select the folder called “inf”.

The Heliophor device driver will install. You may see a Windows Security message similar to the one below. Choose “Install this driver software anyway.”

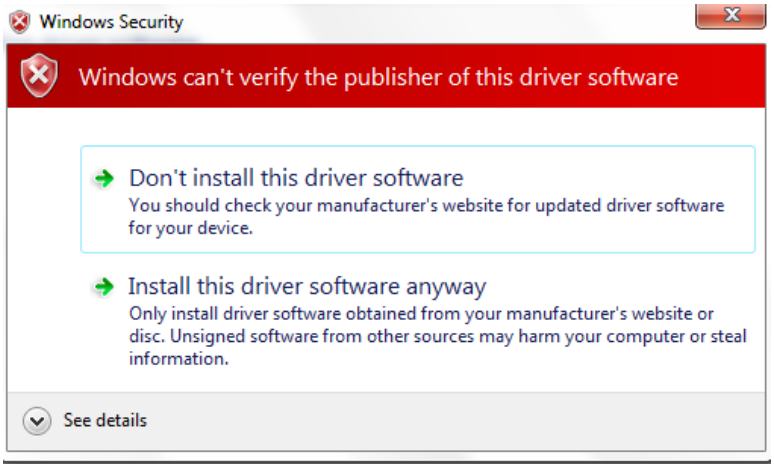


Figure 2 - Windows security screen

The device driver will complete the installation. To confirm, open the device driver and look under “Ports”. You should now see an entry for the “Virtual COM port.” Please note the COM port that has been assigned. You will need to know this COM port designation when you run the HELIOPHOR SOFTWARE (or any other 3rd party software package that supports the Heliophor).

C. HELIOPHOR SYSTEM SET UP

Select a location that allows for adequate air flow as described above. Install the liquid light guide (LLG) by inserting the indicated end into the LLG port on the front of the Heliophor main unit (Figure 3). Failure to properly seat the LLG into the Heliophor may trip the safety interlock and prevent the system from producing light. If this occurs, an error message will appear on the hand controller.

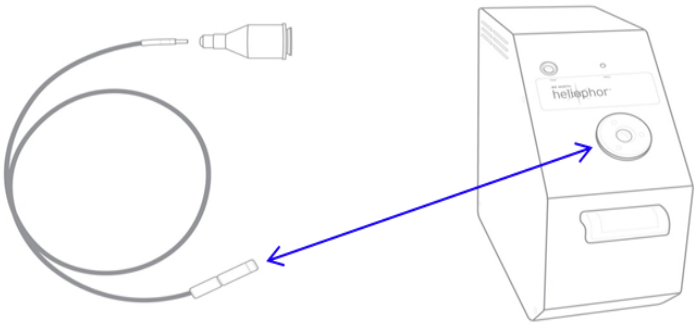


Figure 3 - Schematic of LLG and front of Heliophor

The microscope adapter should now be installed onto your microscope (onto the epifluorescence port). Next, connect the free end of the LLG into the adapter, securing the LLG with the red thumb screw. Ensure that the LLG is fully seated into the adapter.

WARNING: **The microscope end of the liquid light guide has no safety interlock; it must not be directed at anything sensitive to light, including human eyes.**

It is important to ensure that the LLG does not have any tight bends. Tight bends in the LLG can damage it and reduce the total output of light from the LLG (light output may be restricted even if the LLG is not permanently damaged). To avoid such changes in

light throughput, ensure that the LLG is placed in a position where it will be moved as little as possible.

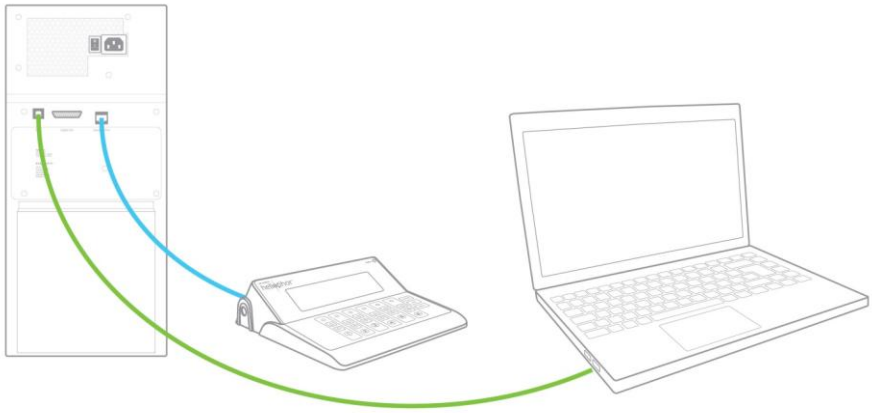


Figure 4 - Schematic of device connections and back of Heliophor

Plug the power cable into the Heliophor unit and then into the wall socket. Position the hand controller for easy access, and then plug the hand controller into the correct port (Figure 4). To allow PC control, use the supplied USB cable to connect the computer to the correct port on the rear of the Heliophor unit (Figure 4). If you have not yet installed the Heliophor device driver, see Section IV.B above.

The Heliophor is now ready to power up; move the rocker switch at the rear of the unit to the “ON” position.

D. STANDBY MODE

The system may also be placed in standby mode using the button on the front of the main unit. Standby mode keeps the system powered up but in a state of reduced power consumption. When in standby mode, the status lights on the front of the system and on the hand controller will flash green. It is perfectly acceptable to leave the system in standby mode for long periods of time.

V. FIRST TIME USE AND CALIBRATION

The Heliophor unit arrives with modules and dichroics installed and ready to use. If fewer than 6 modules are installed in the system, the unused positions will have module blanks installed. It is essential that all unused positions contain module blanks. If a blank is not installed, the fan at that position will run at full power and could adversely affect the thermal management of the system.

An important feature of the Heliophor is its ability to regulate output power and ensure that a constant amount of light is produced over time. Two features ensure this consistent performance:

1) Real-time optical feedback of the light exiting the modules
2) System-wide calibration of the system

The real-time feedback system never has to be calibrated and operates continuously whenever a module is producing light.

The Heliophor's modules are readily reconfigurable. Modules can be added or removed as needed for particular experiments (see Section VI.A). When a module is moved to a different position within the system, the module's output light will be the same (due to the real-time feedback loop); however, that light may pass through a slightly different optical path than in the previous position. The result is that the amount of light leaving the system through the LLG may be slightly different. This difference is compensated for using **system-wide calibration**.

A. SYSTEM-WIDE CALIBRATION

System-wide calibration uses the calibration port on the left side of the hand controller and adjusts the output of each module to ensure that the amount of light leaving the system is consistent. System-wide calibration should be done at the following times:

1) Upon first used after purchase to establish a base-line calibration
2) Following reconfiguration of the modules within the system

To perform an initial system calibration, first turn on the Heliophor. The hand controller should show the "Cal Needed" message and the LED status lights on the hand controller and main unit will flash yellow. Fully insert the LLG into the calibration port on the hand controller unit (Figure 5). The LLG's orientation in the calibration port should be similar its orientation when inserted into the microscope. Avoid tight turns in the LLG; these turns can diminish light throughput.

Figure 5 - Calibration Port on Hand Control Unit

On the hand controller, select the “Menu” button and then press the “4” button to reach the calibration screen (Figure 6).

Figure 6 - Calibration Menu on Hand Control

Ensure the appropriate LLG (3mm or 5mm) is selected. If necessary, press the “3” button to toggle the LLG. Then, press the “2” button to calibrate the system. The system will automatically cycle through the installed modules and measure their output intensities. The hand controller display will then show the “Calibration Worked” message. To clear this message, press the “Dim” button on the hand controller or, in the HELIOPHOR SOFTWARE, select, “File → Clear Warn”. Reinsert the LLG into the microscope. The system is now ready for operation.

Following a reconfiguration of modules within the system, the “Cal Needed” message will be displayed to prompt the user to calibrate. If calibration is not desired at that time, simply clear the message by pressing the “Dim” button on the hand controller or select “File → Clear Warn” in the HELIOPHOR SOFTWARE. The Heliophor can then be used

normally, but the intensity of light leaving the LLG may be slightly different than in the previous configuration.

B. INTERCHANGING THE CALIBRATION PORT ADAPTER

The Heliophor is shipped with either a 5mm or 3mm LLG and a corresponding calibration port adapter. To change to an LLG of different diameter, the calibration port receiver must be changed. The following steps are required to execute this change:

1) Use a 3/32” hex (Allen) wrench to remove the 4-40 x 7/16” socket-head cap screw securing the adapter to the calibration port.
2) Remove and store the calibration port adapter.
3) Remove the dust plug from the new adapter and place the adapter into the calibration port.
4) Secure the new adapter with the 4-40 x 7/16” socket-head cap screws.
5) Follow the above procedure for calibration, ensuring the correct LLG is selected (see above).
6) After successful calibration, insert the dust plug (attached to the installed receiver) fully into the port to ensure dust does not enter the calibration port.

VI. SYSTEM CONFIGURATION

The following instructions address changes to the configuration of the modules within the system.

A. MODULE AND DICHROIC INSTALLATION

Unplug the unit and lay it on its side so the user-accessible side is facing up (this is the right side of the system, when viewing the system from the front). Locate the 7 Philips-head screws that hold the side panel in place and remove them with the provided screwdriver (Figure 7).

Figure 7 - Location of 7 panel screws

On either side of the module, locate the two captive screws that secure the module to the base plate (Figure 8).

Figure 8 - Captive screws for module

To remove a module, use the supplied flat-head screw driver to loosen both captive screws. Then pull the module firmly upwards, taking care to avoid colliding with other components or scratching the filter on the front of the module.

If installing a module into a position that was previously empty, remove the module blank by loosening the two flat-head screws holding it in place, and lift the blank out of the system (Figure 9).

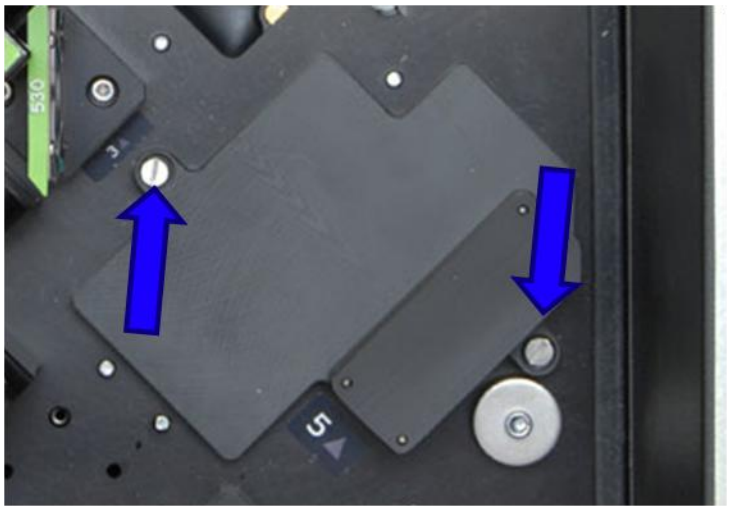


Figure 9 - Module blank

To install a new module, align the electrical connector in the module with the connector in the main unit. Push the module firmly into place and tighten the 2 captive screws. Proper alignment is ensured by the two alignment pins in the bottom of the module. Ensure that the module is flat against the base plate of the main unit.

Installation of a module will be accompanied by installation of the coordinated dichroic. Dichroics are replaced by removing the entire dichroic mount, which is held in place with 2 captive screws (Figure 10). The hex wrench supplied in the tool kit can be utilized to loosen these two captive screws. The dichroic mount can then be lifted out of the main unit.

Figure 10 - Dichroic holder screws

To install a dichroic, align the pins (Figure 11) in the main plate with the holes in the dichroic mount, push firmly to seat, and then tighten the screws. A dichroic must be installed in the correct orientation; the screws will not engage if the dichroic is incorrectly aligned.

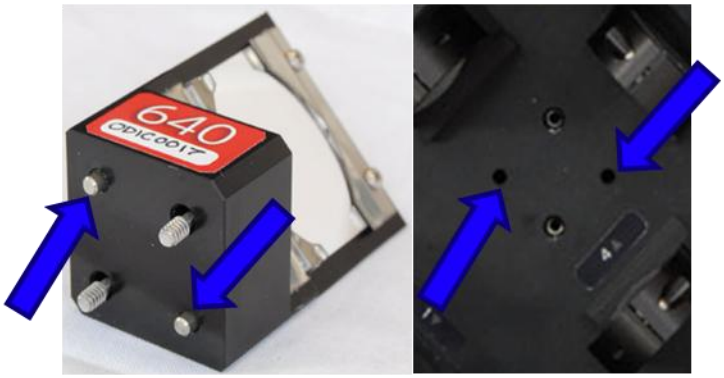


Figure 11 - Dichroic holder alignment pins

When all modules and dichroics have been properly installed, replace the cover and the cover screws.

NOTE:

Modules must be installed such that the lowest numbered positions are occupied first (Figure 12). For example, if three modules are installed, they must be installed in positions 1, 2, and 3. Installing modules into the higher numbered positions without filling the lower numbered slots will result in an error. Furthermore, the modules must be installed in order of ascending wavelength. Failure to install the modules in the proper order will result in an error. Installation errors will prevent the light engine from functioning correctly.

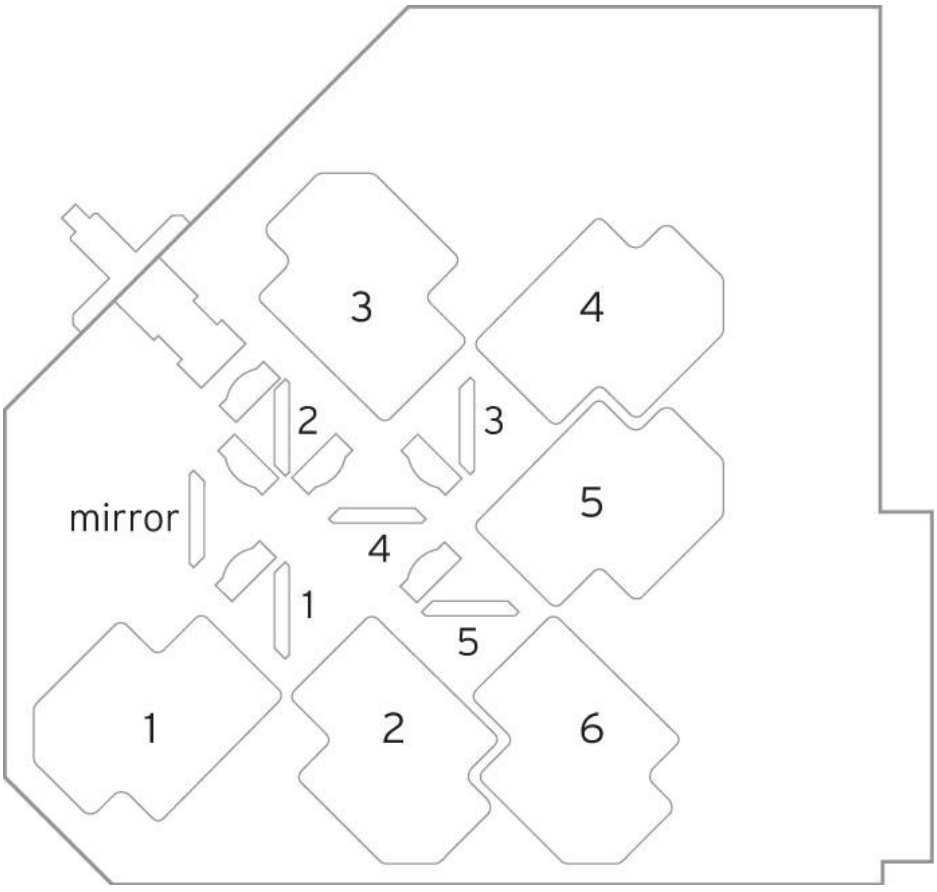


Figure 12 - Schematic of Heliophor light path

B. SPECIAL CASE WHEN ONLY 1 OR 3 MODULES HAVE BEEN INSTALLED

When only 1 or 3 modules are installed in the system, a second full mirror must be installed to direct light to the LLG. This mirror is included with the system and was shipped mounted in a Heliophor mirror holder. The correct positions for the mirror are given in the table below.

Table 2 - Mirror positions

	1 Module Installed	3 Modules Installed
Second Mirror Position	Position 2	Position 4

C. MODULE COMPATIBILITY

The Heliophor modules will provide full output power when there is no spectral overlap between the adjacent module wavelength bands. However, a minimal overlap is permissible when it is required for certain experimental protocols. In such cases, there may be some loss in output power of the longer wavelength module. Certain pairs of modules have spectral overlaps so large that the power output would be compromised if they were installed together; these modules should not be simultaneously installed.

The chart below (Figure 13) indicates whether modules will work together optimally (green), with some loss of power (yellow), or poorly (red). The simultaneous installation of modules that are shown in yellow will result in the display of a warning code: “Spect Overlap” on the hand controller or “Mod Spect Overlap” on the System tab of the HELIOPHOR SOFTWARE. This warning code can be cleared by using either the “Dim” button on the hand controller or the “Clear Warn” menu selection in the “File” menu of the HELIOPHOR SOFTWARE.

If two installed modules have significant overlap, but are not identical (480 and 500 for example), a “Mod Incompat” error will appear on the hand controller. This error cannot be cleared and one of the overlapping modules must be removed.

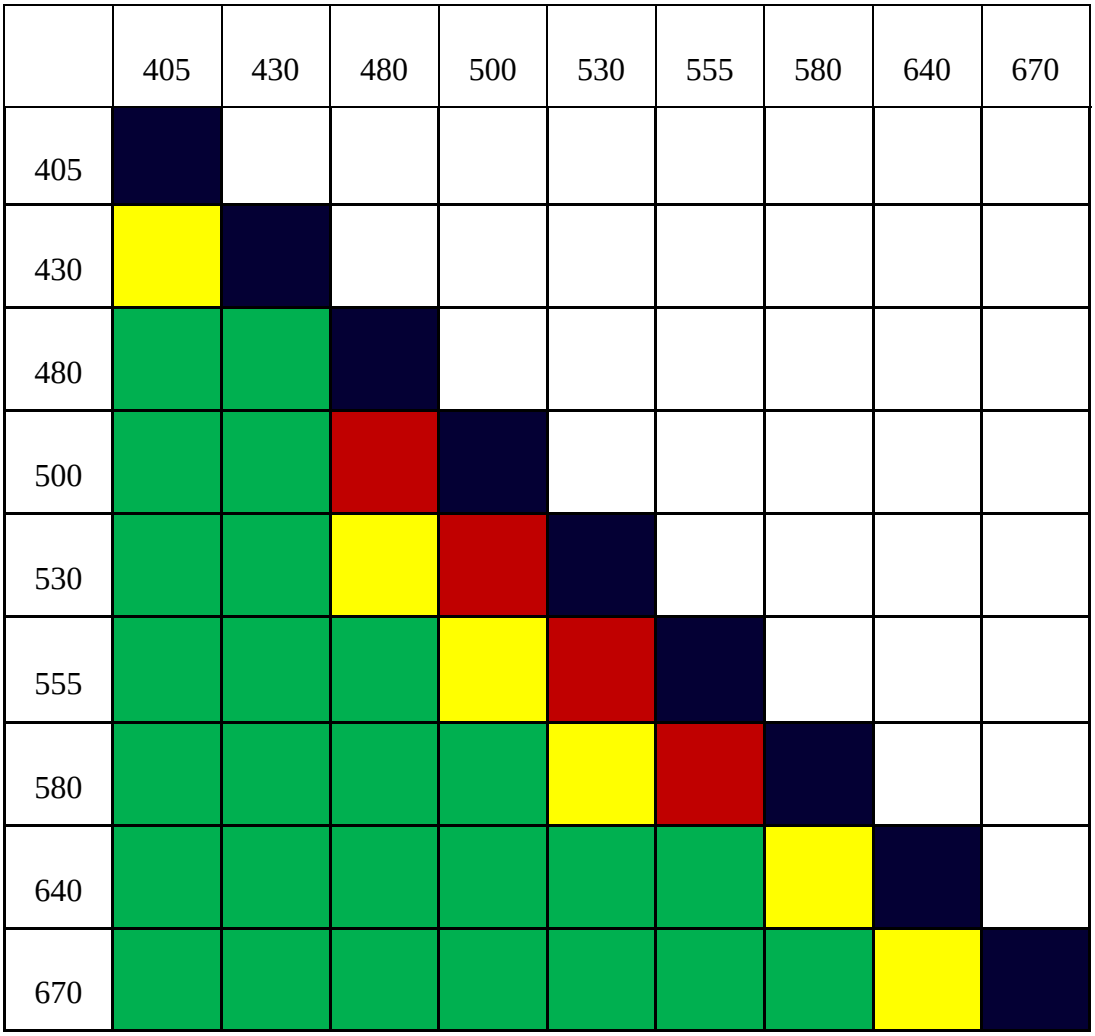


Figure 13 - Module Compatibility Chart

D. DIGITAL I/O

The Heliophor can be controlled in a number of ways, including external TTLs and analog voltages. In addition, the Heliophor can output up to 6 TTLs. All of the digital inputs and outputs (I/O) are contained within the DB25 connector on the back of the system. The pinout for this connector are shown in Figure 14.

The I/O signals can be accessed via a standard DB-25 connector at the rear of the instrument. The pinout is diagramed below (Figure 14). Alternatively, the optional break-out box (P/N 20003-000-000) may be connected to the Heliophor main unit by using a DB-25 cable. The BNC connectors on the break-out box are labeled according to the indicated channel and function.

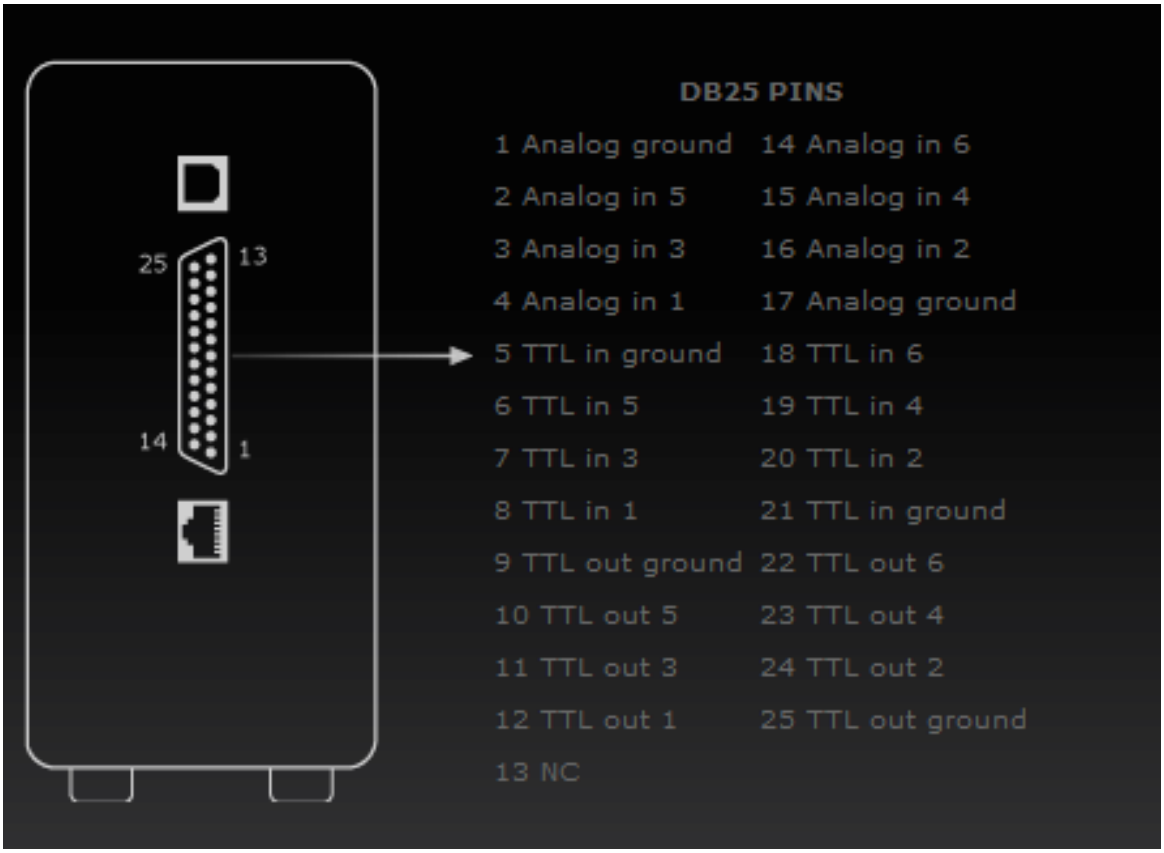


Figure 14 - DB25 pinout

VII. OPERATION AND CONTROL

Using the HELIOPHOR SOFTWARE: Quick Start

1. *With the* HELIOPHOR SOFTWARE *installed and the Heliophor unit turned on, start Heliophor.exe.*
2. *Within the software, locate the* ***Port*** *menu and then select the correct COM port (see* Figure 16*). Following correct selection, installed modules will become highlighted on the diagram at the top of the main screen.*
3. *View the* ***Status*** *tab to verify that the installed firmware is the latest version, as listed on www.89north.com*
4. *Use the* ***Basic*** *tab to perform simple operations. Turn modules on and off by selecting or de-selecting their check boxes and clicking Enable/Disable. Specify power outputs by adjusting the sliders.*

Note: Details on all menus and tabs follow the Quick Start information.

There are three options for controlling and setting up the Heliophor: the hand controller, the HELIOPHOR SOFTWARE, or a third-party software package. The hand controller allows for basic control of the Heliophor and quick adjustments to module intensity. In addition, the hand controller can enable TTL and analog voltage control, as well as run and stop programs and initiate system calibration.

The HELIOPHOR SOFTWARE allows for more advanced control, including the creation of programs. The HELIOPHOR SOFTWARE and hand controller are designed to work together, and the user need not choose between them.

A. HELIOPHOR SOFTWARE INTERFACE

The HELIOPHOR SOFTWARE allows for full control of the Heliophor system. This software is included with every Heliophor and can be downloaded from our website (www.89north.com).

The upper section of the screen shows the light path schematic, which also indicates which modules are installed. The light path will be highlighted for any module that is powered on. Note that when high-speed wavelength switching occurs, the light path diagram display only shows snapshots of which modules are active.

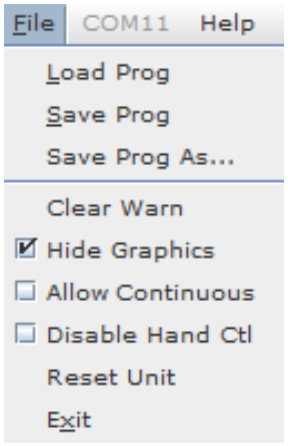


Figure 15 - File Menu

The top bar of the screen displays 4 menus and the bottom portion shows 5 tabs. The menus (**File, Port, Update,** and **Help**) and 5 tabs (**Basic, Advanced, Program, Status, and System**) will be covered in detail below.

1. MENUS

a. **File** Menu - The **File** menu allows access to *Program Sets* and the configuration of the basic aspects of the system.
   i. **File > Load Prog** loads a *Program Set* from a text file.
   ii. **File > Save Prog** saves a *Program Set* to a text file.
   iii. **File >Save Prog As…**saves a *Program Set* under a new name.
   iv. **File > Clear Warn** clears any warnings or non-fatal errors. Note that fatal errors cannot be cleared using this command and may only be cleared by cycling the power. See Section X for more information on warnings and errors.
   v. **File > Hide Graphics** hides the light path schematic and pinout graphic shown at the top of the HELIOPHOR SOFTWARE screen.

vi. **File > Allow continuous** over-rides the automatic module shut-off that occurs after 15 minutes of continuous use; selecting this option will allow the module to run for longer than 15 minutes continuously.
vii. **File > Disable hand Ctl** disables the hand control (this option is useful for preventing accidental changing of settings when an experiment is running).
viii. **File > Reset Unit** resets the Heliophor system without cycling the power.
ix. **File > Exit** closes the HELIOPHOR SOFTWARE.

b. **Port** Menu - The **Port** menu allows the user to specify the COM port to which the Heliophor is attached. Note that it is possible for a single PC to control multiple Heliophor units through different COM ports (this also requires that the PC have multiple copies of the HELIOPHOR SOFTWARE open). The "simulator" option can be selected to run the Heliophor GUI without requiring a connection to a Heliophor. This "simulator" mode may be useful for writing and editing programs.

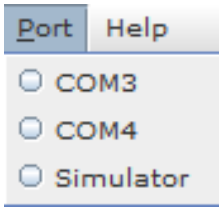


Figure 16 - Port Menu

c. **Help** Menu - The **Help** menu displays the version of the HELIOPHOR SOFTWARE currently being run. Additionally, it links to an electronic copy of this manual.

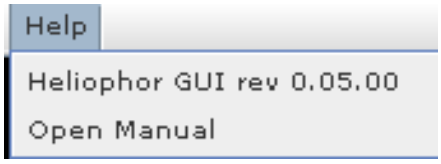


Figure 17 - Help Menu

2. TABS

a. **Basic** Tab - The **Basic** tab allows control over the essential aspects of each installed module. Modules may be selected or deselected using the check box to the right of the module listing; all selected modules may then be turned “ON” by clicking the “Enable/Disable” button at the bottom of the screen. When in the “Enable” state, each module may be turned off individually by deselecting its check box. A maximum of 4 modules may be simultaneously powered on. The power output of each module may be adjusted using its slider.

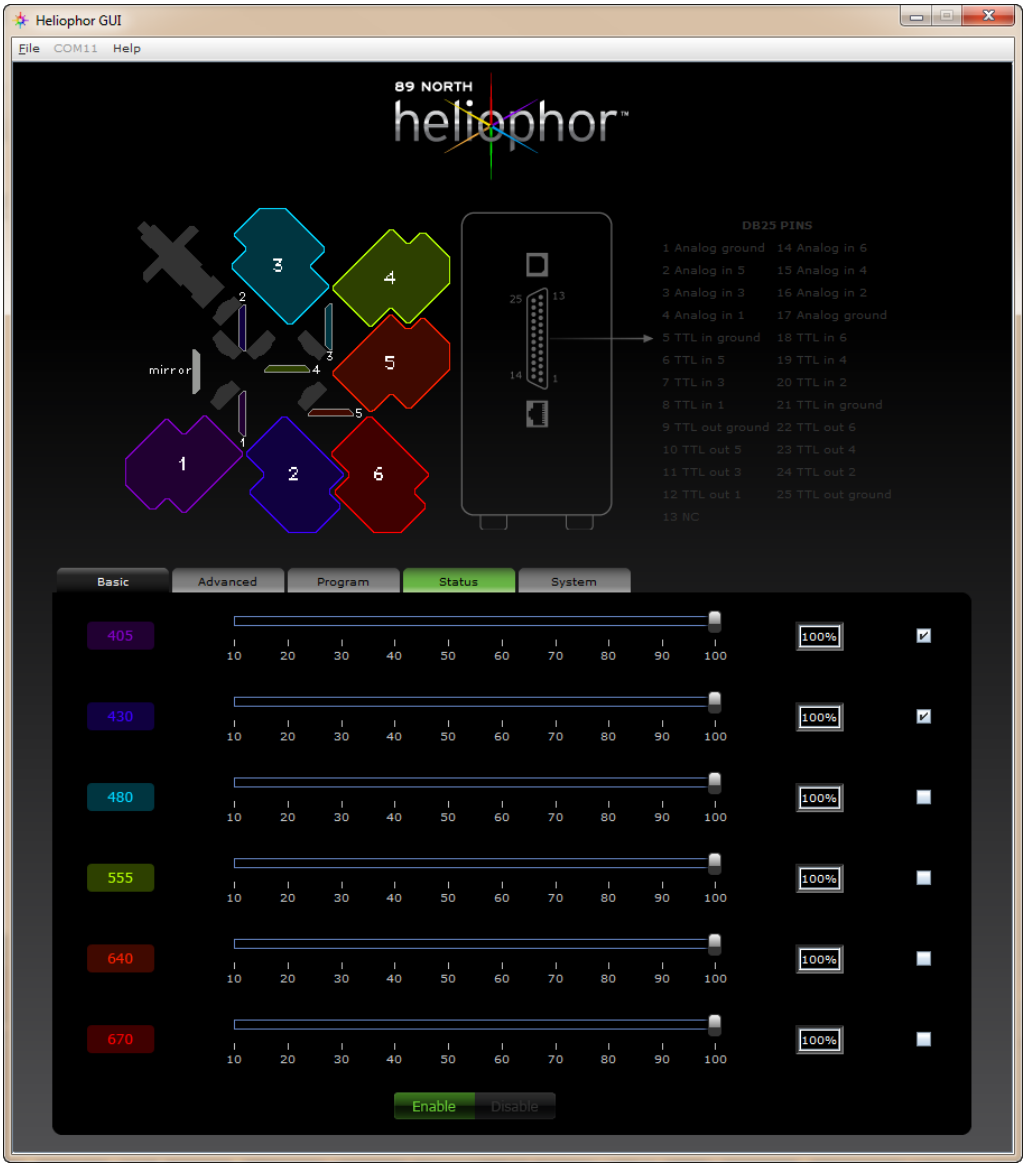


Figure 18 - Basic Tab

b. **Advanced** Tab - The **Advanced** tab enables additional flexibility in the control of the Heliophor's output intensity and the on/off states of individual modules. Using the radio buttons at the top of the **Advanced** tab, the user can specify whether the **Basic** tab or an analog voltage will be used to control module intensity. The on/off state of the modules can be controlled through the **Basic** tab (TTL input checkbox not selected) or via external TTL signals (TTL Input check box selected). The resulting functional combinations are described below.

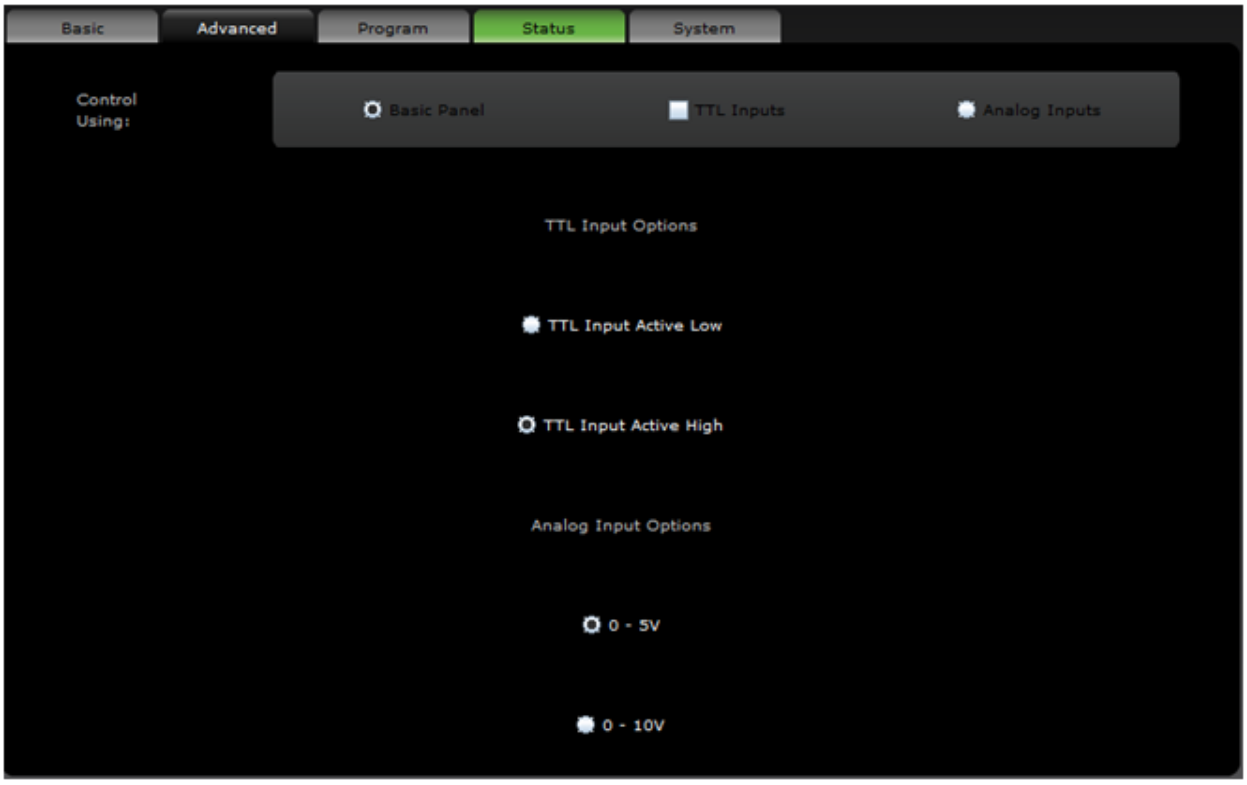
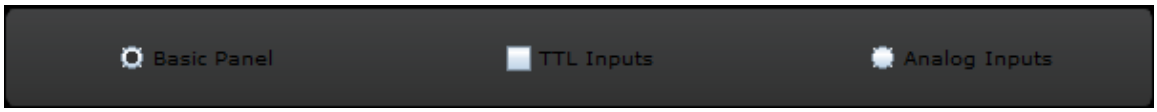


Figure 19 - Advanced Tab

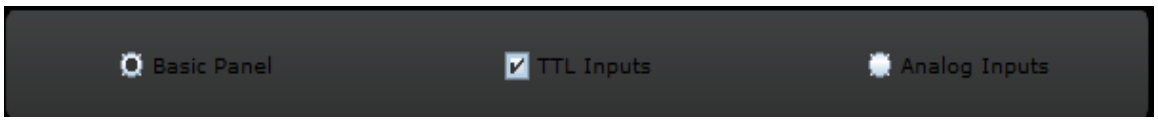
i. **Basic** Mode - To utilize this mode, select the **Basic** Panel



The **Basic** option allows the user to utilize the **Basic** tab to maintain control of the modules' power and intensity using the **Basic** tab (rather than using an external signal). As outlined above, the modules' intensities are controlled using the sliders; the modules are turned on and off using the "Enable" button

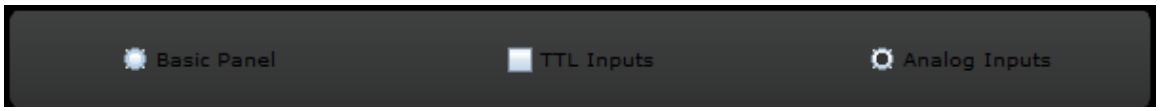
and the check boxes. In **Basic** mode, the hand controller can also be used to control intensity and to turn modules on or off.

ii. **BasicTTL** Mode - To utilize this mode, select **Basic** Panel and check TTL Inputs



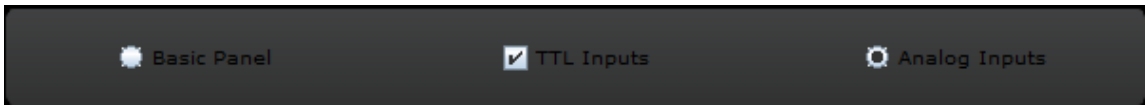
BasicTTL mode enables a module to be turned on and off by an external TTL input signal. Each module has its own dedicated TTL channel. The intensity, however, continues to be controlled using the **Basic** tab or the hand controller. When the **TTL Inputs** option is utilized, the user must also specify whether the power should be turned on by a low or high TTL signal. The "TTL Input Active Low" button indicates that a low TTL signal will turn the specified module on; the "TTL Input Active High" button indicates that a high TTL signal will turn the power on.

iii. **Analog** Mode - To utilize this mode, select **Analog Inputs**



The **Analog** option allows an analog signal to turn the modules on and off and to control their intensities. The user specifies the voltage range of the analog signal using the two radio buttons at the bottom of the tab. For an analog range of 0-5 V, a voltage range of 0-0.5 will correspond to power OFF. Voltages of 0.5-5 correspond linearly to intensities of 10-100% (that is, 2.5 V would correspond to 50% intensity). Likewise, for an analog range of 0-10 V, a voltage range of 0-1 will correspond to power OFF. Voltages of 1-10 correspond linearly to intensities of 10-100% (that is, 5 V would correspond to 50% intensity). If the intensity control analog voltage is valid (i.e, 0.5-5 V or 1-10 V), the on/off status of a module can be controlled by either the HELIOPHOR SOFTWARE or the hand controller.

iv. **AnalogTTL** Mode - To utilize this mode, select **Analog Inputs** and check **TTL Inputs**



In **AnalogTTL** mode, the module intensity is set via an analog voltage, and the modules are turned on and off via a TTL signal. To turn on a module, the TTL input must be in the active state, and the analog input must be set to greater than or equal to 10% intensity.

c. **Program** Tab - The **Program** tab allows the user access to the programming functionality of the Heliophor. This section will cover how to run and stop programs. The creation of new programs and editing of existing programs is covered in the Programming section of this manual (Section VIII).

Figure 20 - Program Tab

A group of programs is called a *Program Set*. A *Program Set* can contain up to 8 programs. While, multiple *Program Sets* can be stored on a host computer, only one *Program Set* can be loaded into the Heliophor at a time. As outlined above, *Program Sets* can be saved and loaded using the commands in the **File** menu.

Once a *Program Set* is loaded on the system, the individual programs in that set will populate the drop down menu on the **Program** Tab.

From here, specific programs can be selected (Figure 21). The HELIOPHOR SOFTWARE includes a default Program Set; details on the programs contained in this default Program Set can be found in the Programming section of this manual (Section VIII).

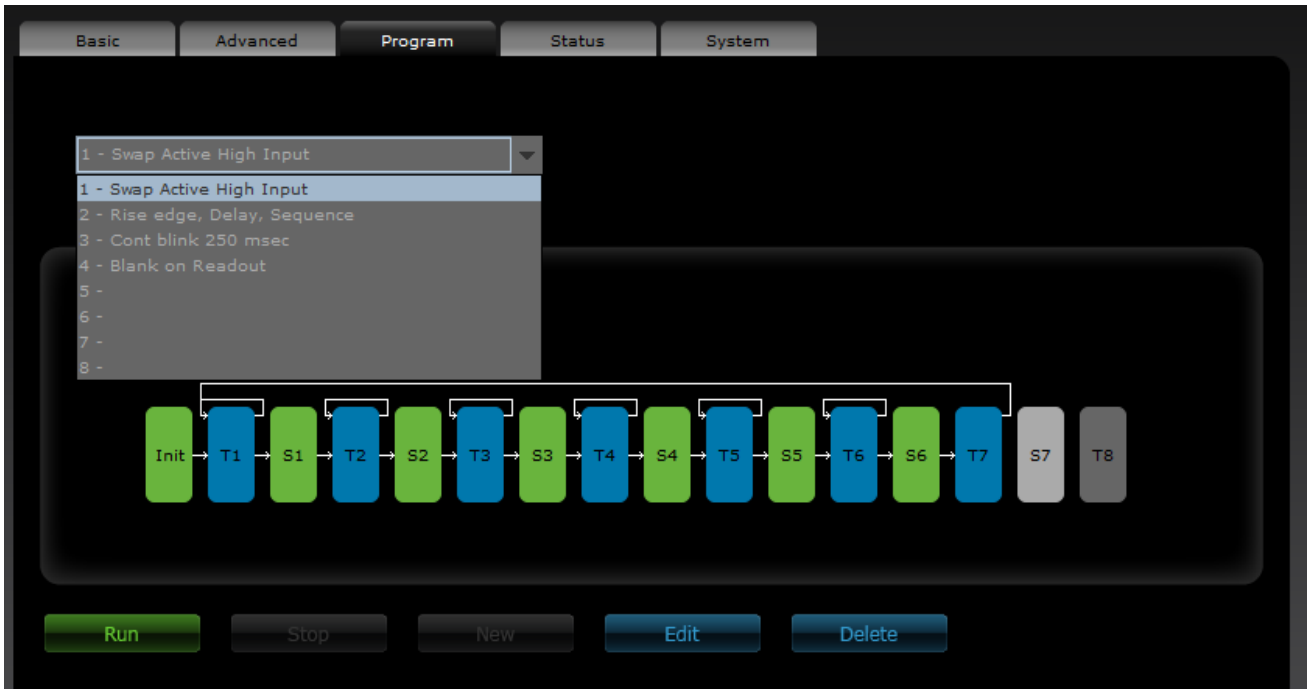


Figure 21 - Program drop-down list

When a program is selected, its visual representation is displayed in the program tab. Again, more details of this representation will be found in the Programming section of this manual (Section VIII).

The **Program** tab also contains the following 5 buttons:

- **Run** - Runs the selected program.
- **Stop -** Stops a running program. This is only required for programs that run in loops; programs with a defined end will stop automatically.
- **New** - Opens a window to allow the user to write a new program. To create a new program, select a program position with no program name (i.e., only a number listed in the drop down list) and click “New”. More details on programming can be found in the Programming section of this manual (Section VIII).
- **Edit** - Allows the user to edit an existing program. To modify a program, select an existing program from the drop down list and click ”Edit”. More

details on programming can be found in the Programming section of this manual (Section VIII).

- **Delete** - Removes the program currently selected in the drop down menu.

Note that all of these functions modify the *Program Set* loaded onto the Heliophor. If these programs were originally loaded from a host computer, the files on the host computer will remain unchanged until the user saves the *Program Set* back to the host computer (this is done via the **File** menu).

d. **Status** - The **Status** tab reports the condition of the system and allows manual control of the output TTLs. The color of the tab indicates the system status and mimics what is seen on the hand controller and system status LEDs.

Figure 22 - Status Tab

The **Status** tab contains the following sections:

i. *Main Controller* - The Main Controller section contains the following fields:

- *Status* - Displays warnings or errors. If no errors are present, it displays the message “No Error”.

- *Prog Status* - Displays information on a program and provides information during firmware updates.
- *TTL Output* – Allows output TTL signals to be turned on and off. The 6 subfields correspond to the 6 output TTL channels, with channels 1 through 6 displayed from left to right. To change the TTL state of a channel, click on the field and select “0” (TTL out low) or “1” (TTL out high).

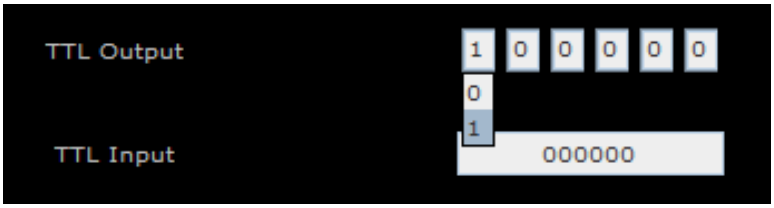


Figure 23 - Setting TTL output level

- *TTL Input* – Displays the current status of each of 6 input TTL signals, with channels 1 through 6 displayed from left to right. A “0” indicates TTL low and a “1” indicates TTL high.

ii. *Hand Controller* – The Hand Controller section contains a *Status* field which displays warnings or errors. If no errors are present, “No Error” is displayed. If no hand controller is installed, “No Handcontrol” is displayed.

iii. *Module Info* – The Module Info section contains a *Status* field for each module position for communicating warnings or errors. If no errors are present, “No Error” is displayed. If no module is installed in a given position, “Not Installed” is displayed for that position. In the special case where no modules are installed in the system, ”Virtual Module” is displayed.

e. **System** Tab - The **System** tab provides basic information about the Heliophor main unit, the hand controller, and each module. For each element, the product ID, serial number, and firmware version are indicated. For the modules, the wavelengths are also included. This information allows users to ensure that the firmware is up to date and may be requested when the user seeks product support from 89 North.

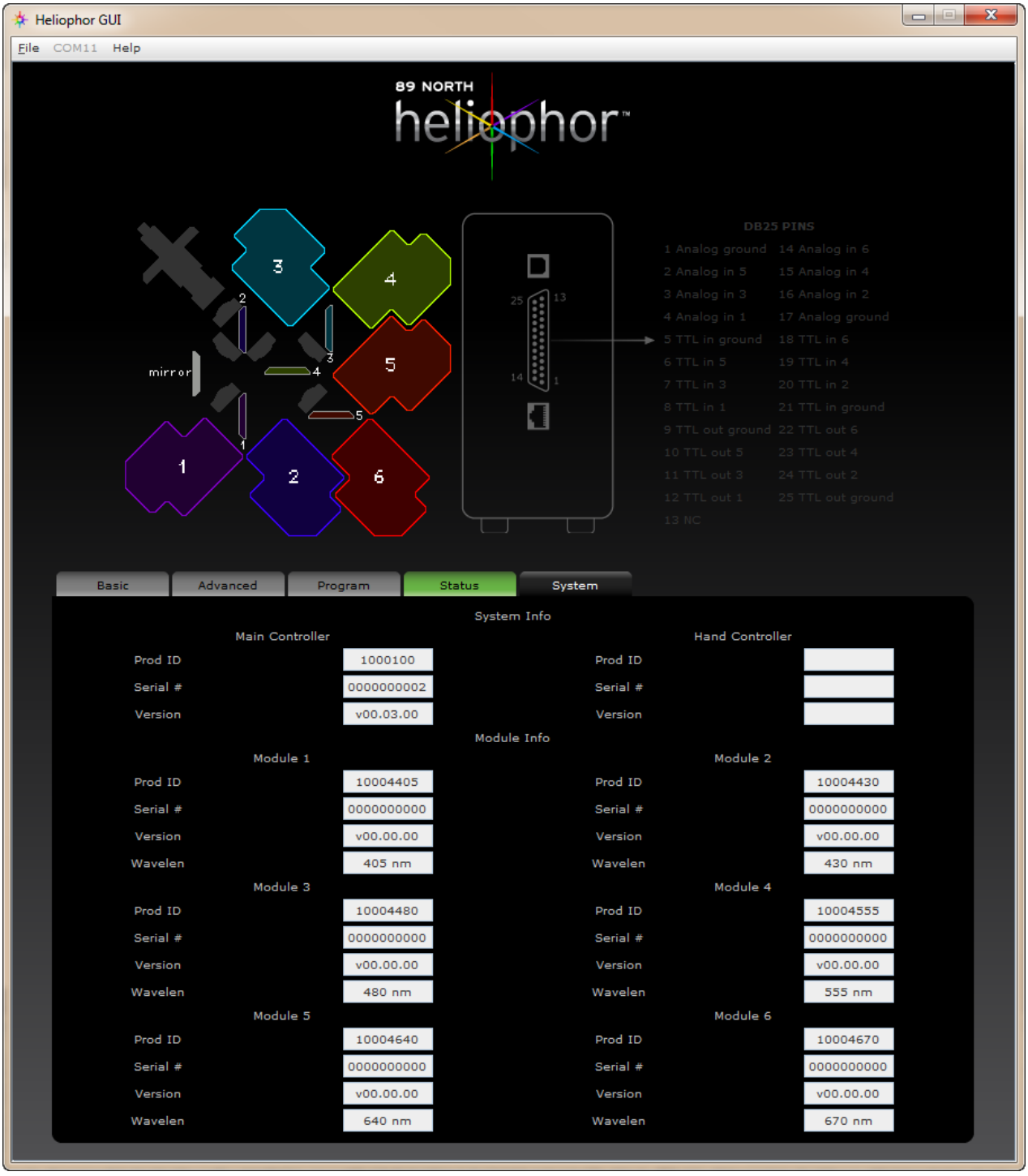


Figure 24 - System Tab

B. HAND CONTROL

1. FUNCTIONAL ELEMENTS

The hand controller unit allows for control of most functions of the Heliophor (except creating and editing programs). It contains the following elements:

a. Display screen
b. System status LED (top right)
c. Six sets of module controls to control the intensity and power of each module:
d. Pressing the numbered buttons will turn the corresponding modules on and off. If using the HELIOPHOR SOFTWARE, these changes will be reflected on the light path schematic shown at the top of HELIOPHOR SOFTWARE.
e. The up and down arrows adjust the power of each module. Holding an arrow button down for 4 seconds or longer will adjust the power in 10% increments.
f. The On/Off button toggles the Heliophor into and out of standby mode (in standby mode, the power is turned off to the modules, fan, and other components, but the main power to the system remains on). The green light on the hand controller will flash when the Heliophor is in standby mode.
g. The dim button turns off the display to minimize light in the room when performing a light-sensitive experiment. In the case of a warning, the Dim button is used to clear the warning (see Section X).
h. The Menu button enters into advanced functions and will be discussed below.
i. Calibration port is used for system calibration after reconfiguring the system.

2. DISPLAY

The main screen of the hand controller displays the following information:

a. Installed modules are labeled by their wavelength (e.g., “480nm”). If no module is installed, the position is listed as “Empty”.
b. Current intensity of the module is displayed as a value between 10% and 100%.
c. If a module is on, the small status light above the intensity control buttons will display the same color as the module (unless the system is in “DIM” mode).
d. The top right-hand corner of the screen displays errors associated with the hand controller (lower line) and errors or warnings occurring at the system level (upper line). See Section X for more information on error codes and their resolutions.
e. In the upper left, the current system mode is shown. The system may take on any of the 5 modes described below:

Figure 25 - Close up of hand controller screen

i. Basic – In this mode, only the simplest actions may be performed. These actions include controlling module On/Off and intensity using the hand control buttons or the HELIOPHOR SOFTWARE. Programs or control using TTL or analog voltage are not supported in this mode.

Figure 26 - Basic mode

ii. PRun – This mode occurs when a program is running. All hand control functions are locked out except in the Program menu.

Figure 27 - PRun mode

iii. BasicTTL – The mode corresponds to TTL control over the modules' On/Off status. Intensity is determined by the hand controller or using the Basic tab in the HELIOPHOR SOFTWARE.

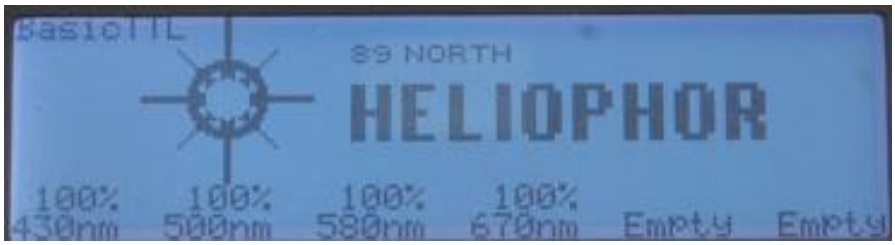


Figure 28 - BasicTTL mode

iv. Ana – In this mode, the intensity of each module is controlled by analog voltages. The On/Off status may be controlled by the analog voltage, the HELIOPHOR SOFTWARE, or the hand controller.

Figure 29 - Ana mode

v. AnaTTL – In this mode, the modules' intensities are controlled by an individual analog voltage. The On/Off status is controlled via TTL.

Figure 30 - AnaTTL mode

3. HAND CONTROLLER MENUS

The menus of the hand controller are accessed via the Menu button. To navigate through the menus, click the numbered button on the hand controller that corresponds with the number listed on the menu (Figure 31).

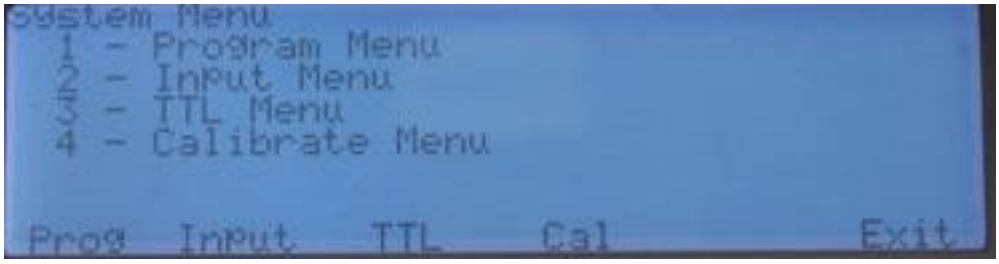


Figure 31 - System menu on hand controller

a. Program Menu – provides access to loaded programs

   i. 'Run Program': Press the ① button to run the selected program

   ii. 'Stop Program': Press the ② button to end the program

   iii. 'Change Selected Program': Press the ③ button to choose a program from those currently loaded; pressing the ③ button will scroll through the list of available programs, with the selected program name displayed below the menu (not shown in figure)

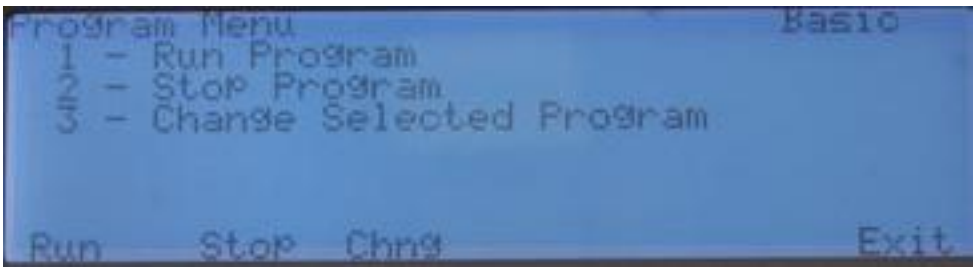


Figure 32 - Program menu on hand controller

b. Input Menu – provides options for selecting control inputs

   i. 'Basic or Analog Input': Press the ① button to toggle between basic (control via hand control buttons or HELIOPHOR SOFTWARE) and analog input modes

   ii. 'Use TTL Inputs for Enable': Press the ② button to toggle between TTL or no TTL inputs

   iii. 'TTL Input Active Hi or Active Lo': Press the ③ button to toggle between active high or active low TTL inputs

   iv. '5 V or 10 V Input': Press the ④ button to toggle between 5V and 10V inputs (when using analog inputs for module control)

v. ‘Mod off after 15 min Current State’: Press the ⑤ button to toggle between “15Min” (automatic shut-off modules after 15 minutes of being on continuously) or “Cont” (continuous operation with no automatic shut-off)

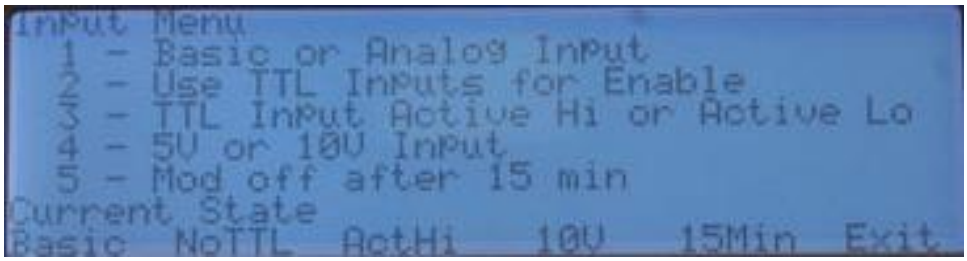


Figure 33 - Input menu on hand controller

c. TTL Menu – provides selection of TTL output channels and indication of TTL input status

i. ‘TTL Out’: Use the up arrow buttons (▲) to change the state of TTL output channels; pressing the a channel’s up arrow results in the TTL output for that channel changing states (from low to high or high to low)

ii. ‘TTL In’: Displays the current status of TTL inputs, with “0” indicating TTL low and “1” indicating TTL high

Figure 34 - TTL menu on hand controller

d. Calibration Menu – provides access to calibration options

i. ‘Check Calibration’: Press ① to run the calibration routine; executes calibration routine but does not make any changes to the system (see Section V.A)

ii. ‘Recalibrate’: Press ② to recalibrate and adjust the system according to the new values obtained during calibration

iii. ‘Light Guide’: Press ③ to toggle between a 3mm and 5mm liquid light guide configuration

Figure 35 - Calibration menu on hand controller

At any point in navigating the menus, you may return to the previous screen using the ⑥ button. To return to the home screen, press the Menu button.

VIII. PROGRAMMING

Programming allows the Heliophor to perform a preprogrammed sequence of events using internally or externally generated triggers. Programs are stored in groups called *Program Sets*. Each *Program Set* can contain up to 8 individual programs. A single *Program Set* is loaded into the Heliophor at a time, but the host computer can contain multiple *Program Sets*. As described previously, *Program Sets* are loaded to the Heliophor and saved back to the host computer via the **File** menu.

To program the Heliophor, two types of actions are utilized: states and transitions:

- **States** are used to specify module intensity, turn the modules on and off, and enable and disable output TTLs.
- **Transitions** specify "where to go next", the input to look for, and/or to delay.

States tell the Heliophor what to do and **transitions** tell it when to do it. A program is a series of alternating transitions and states. All programs start with an **Initial State**.

There are two ways to create programs and *Program Sets* for the Heliophor:

- Use the Program tab in the HELIOPHOR SOFTWARE.
- Create a properly formatted .txt file. This .txt file can contain up to 8 programs and the complete .txt file is considered a *Program Set*.

A. USING HELIOPHOR SOFTWARE PROGRAM TAB

1. CREATING A NEW PROGRAM

To create a new program, select an empty program from the drop-down list on the **Program** Tab and click "New" (Figure 36).

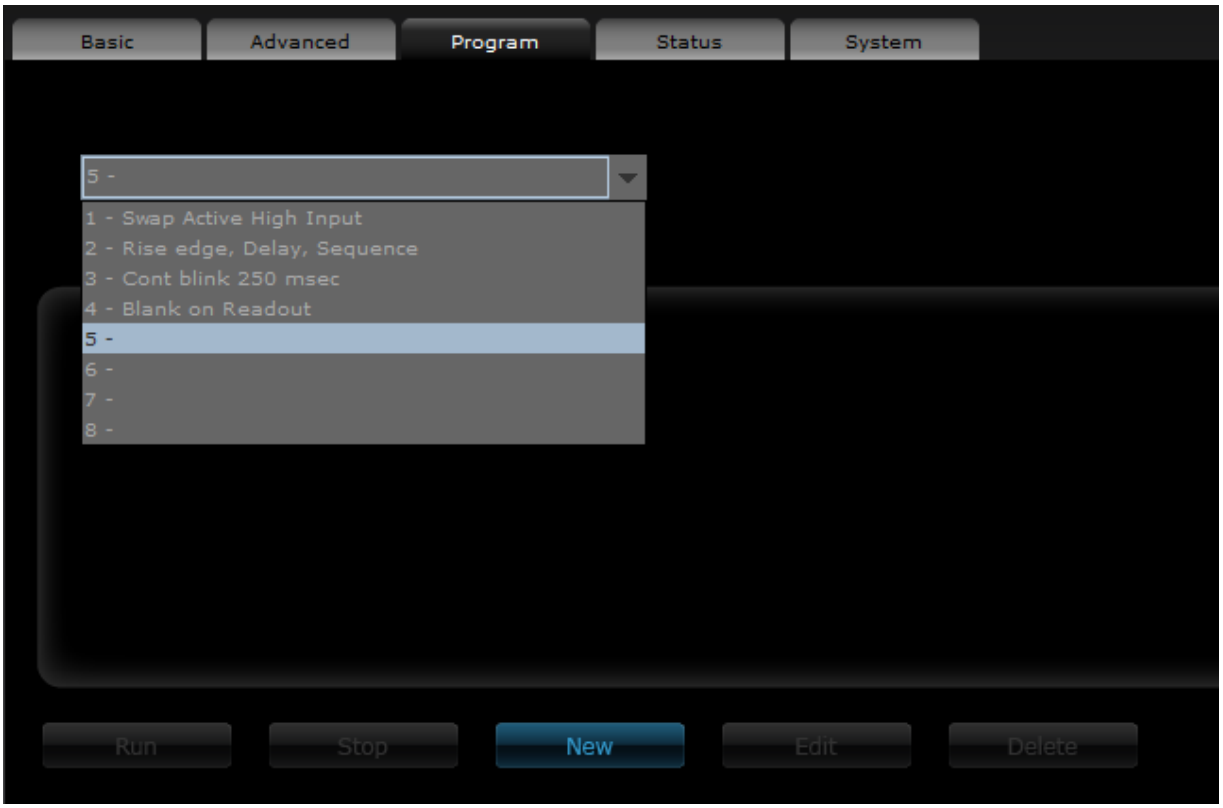


Figure 36 - Create new program from program tab

The program edit window will open (Figure 37).

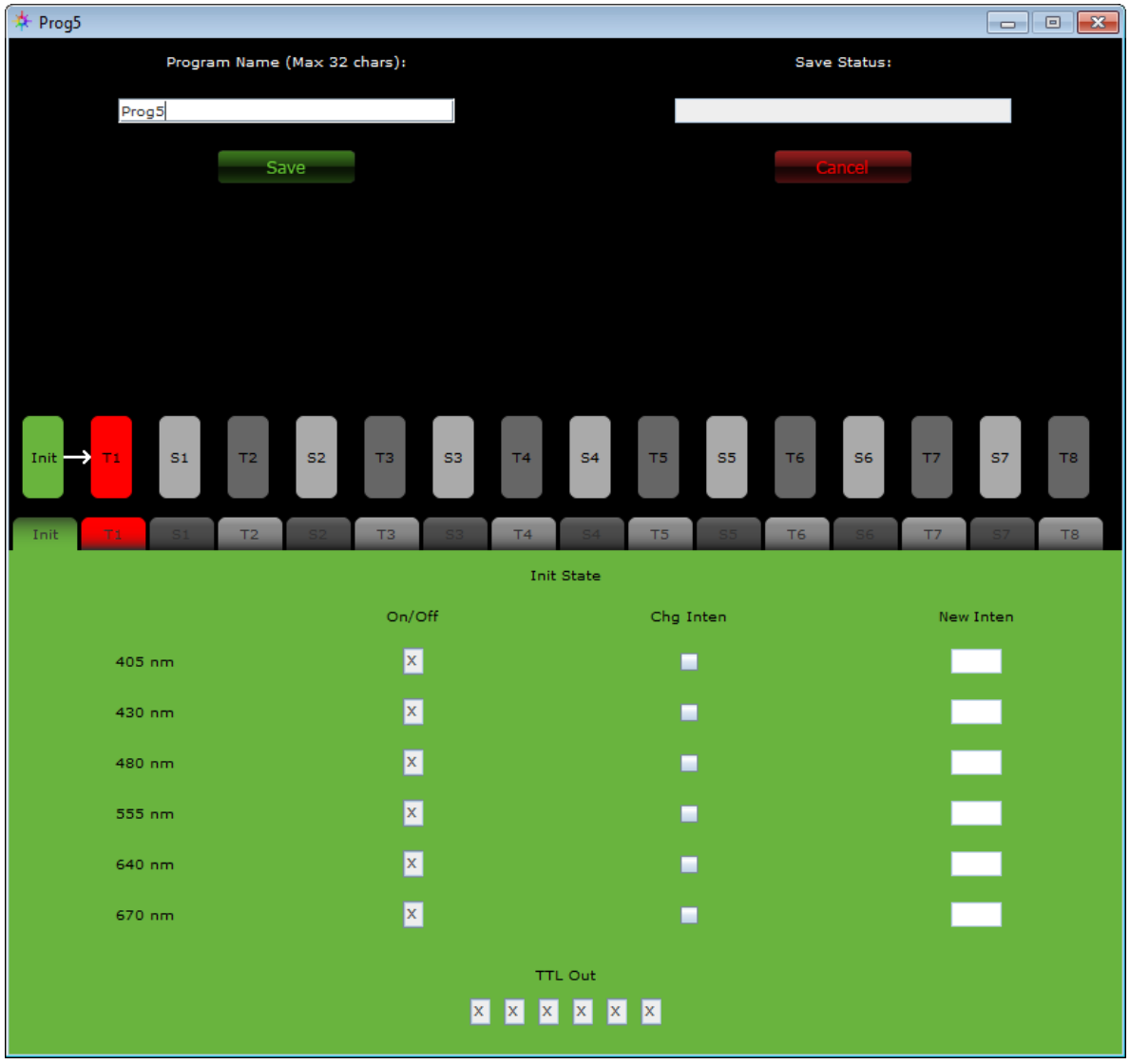


Figure 37 - Program edit window for new program

The program name is specified in the “Program Name” field (upper left corner) and is limited to 32 characters. To save the program to the Heliophor, click the green “Save” button.

When a program is saved, it is checked for errors. If errors are detected, they are displayed in the “Save Status” field. If errors are reported, simply correct them and resave the program.

When making changes to a single program, recall that it is only one program from the loaded Program Set. To save the entire Program Set to the host computer, use “Save Prog” or “Save Prog As…” in the **File** menu.

2. EDITING AN EXISTING PROGRAM

You can also edit an existing program. To do so, select an existing program from the Program List and click “Edit”. In Figure 38, the program “Swap Active High Input” is being chosen for editing.

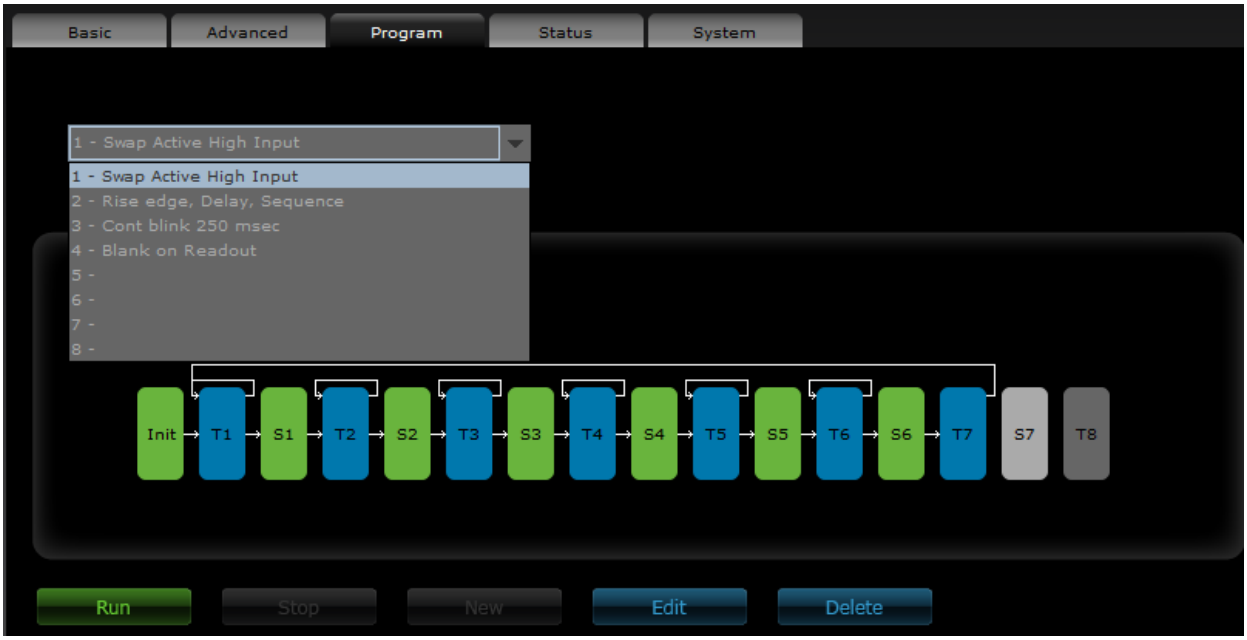


Figure 38 - Select existing program to edit

Once an existing program is selected, the Program edit window shown in Figure 39 will appear.

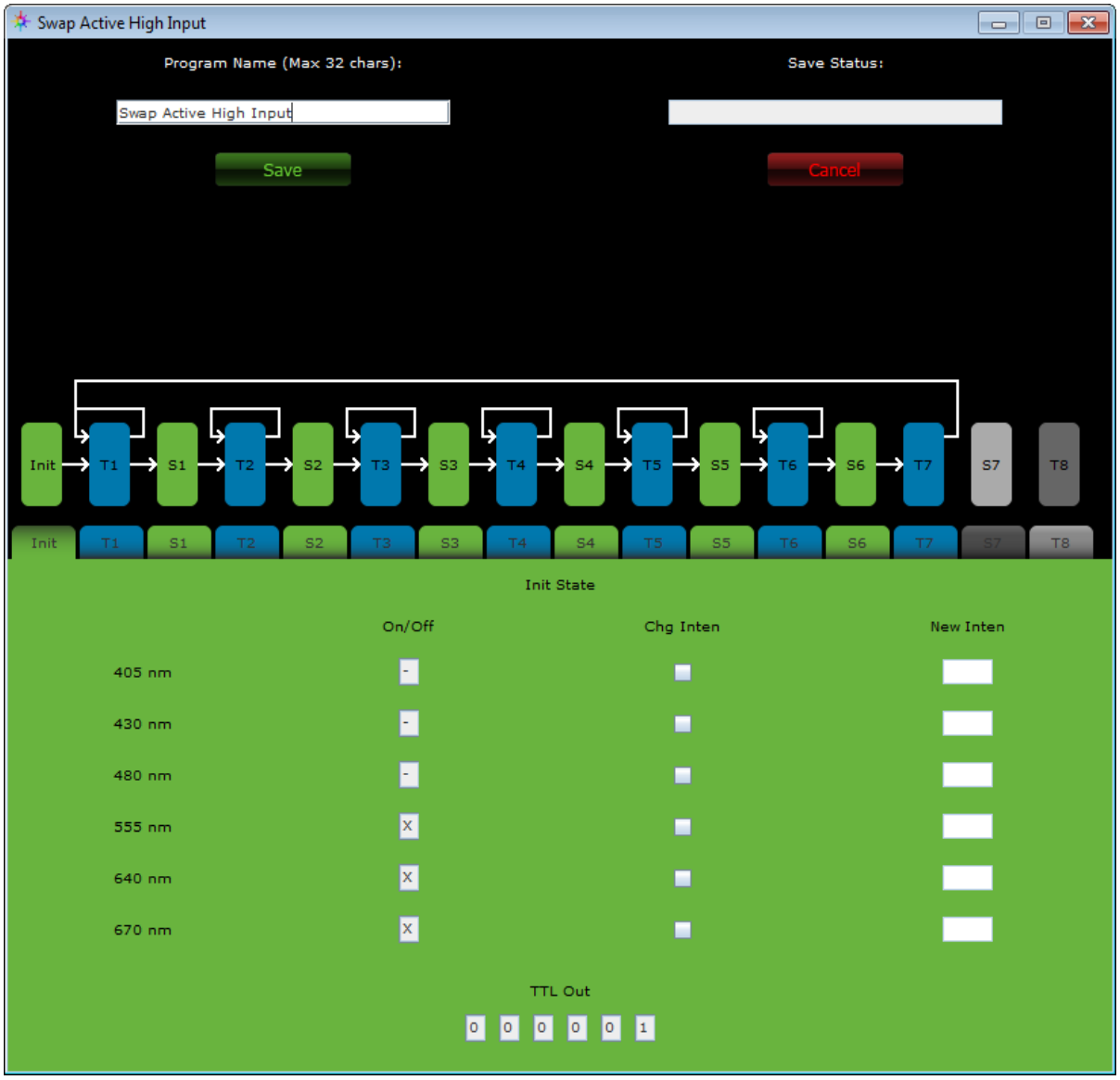


Figure 39 - Program edit window of existing program

3. USING THE PROGRAM EDIT WINDOW

As described above, there are two components that compose programs: states and transitions. These components are shown as a linear array of tabs on the Program Edit screen.

a. **Init** Tab - The first tab is labeled “Init”, which indicates the Initial State. This tab allows the user to specify the starting conditions of all the modules and the TTL outputs.

i. The **Init** tab has 4 columns of information:
   - Module names (no header) - Lists all installed modules by wavelength.
   - *On/Off* - Specifies if the module is on or off at the start of the program using the following nomenclature:

     "–" indicates the module should be turned OFF

     "+" indicates the module should be turned ON

     "X" indicates no change should be made to the module

     Up to 4 modules can be turned on simultaneously.
   - *Chg Inten* - When unchecked, the intensity of the module will use the current intensity found on the basic tab. If checked, the "New Inten" field becomes active (see below).
   - *New Inten* - Indicates the initial intensity value (expressed as percentage, 10-100) that a module should assume. Note that this value overrides the intensity set on the "Basic Tab." As explained above, specifying the intensity value is only an option when the "Chg Inten" box is checked.

ii. In the *TTL Out* section of this tab, there are also 6 entries for TTL outputs that can be changed by clicking on each one and selecting a value of "0" (TTL low/off), "1" (TTL high/on), or "X" (no change).

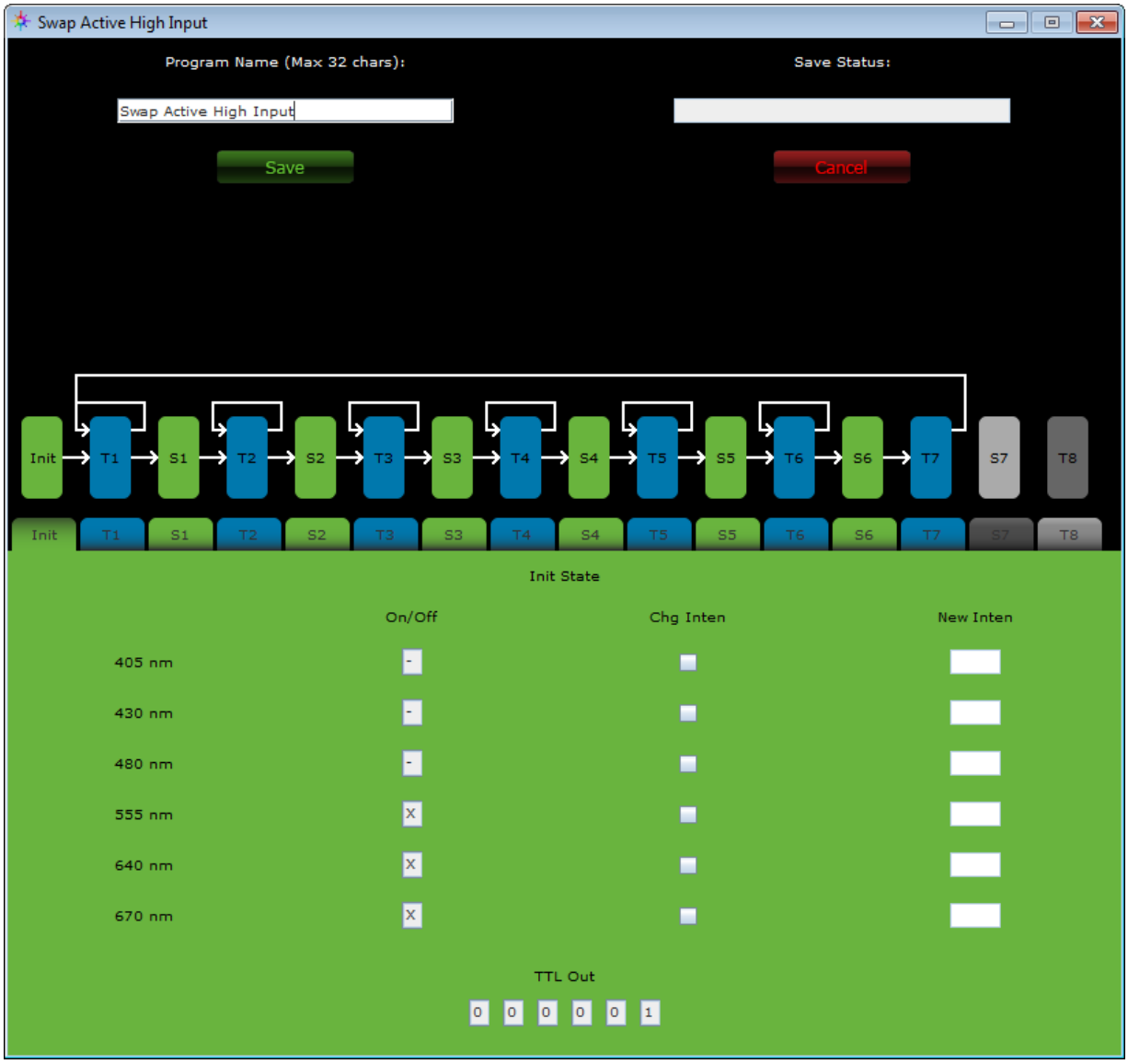


Figure 40 - Initial State

b. State Tabs, **S1** through **S8** - The state tabs are identical to the Initial State screen described above and shown in Figure 40. These tabs allow the user to specify module operating parameters for states subsequent to the initial state. Undefined or unused states are indicated by gray tabs.

c. Transition Tabs, **T1** through **T8** – An example of a transition tab is shown in Figure 41. These tabs allow the user to specify transitions between states as well as the end point for a non-looping program. Undefined or unused transitions are indicated by gray tabs. A transition which ends the program, i.e. “Stop” (see

Table 3), is indicated by a red tab. By default, all transitions are configured as "Stop".

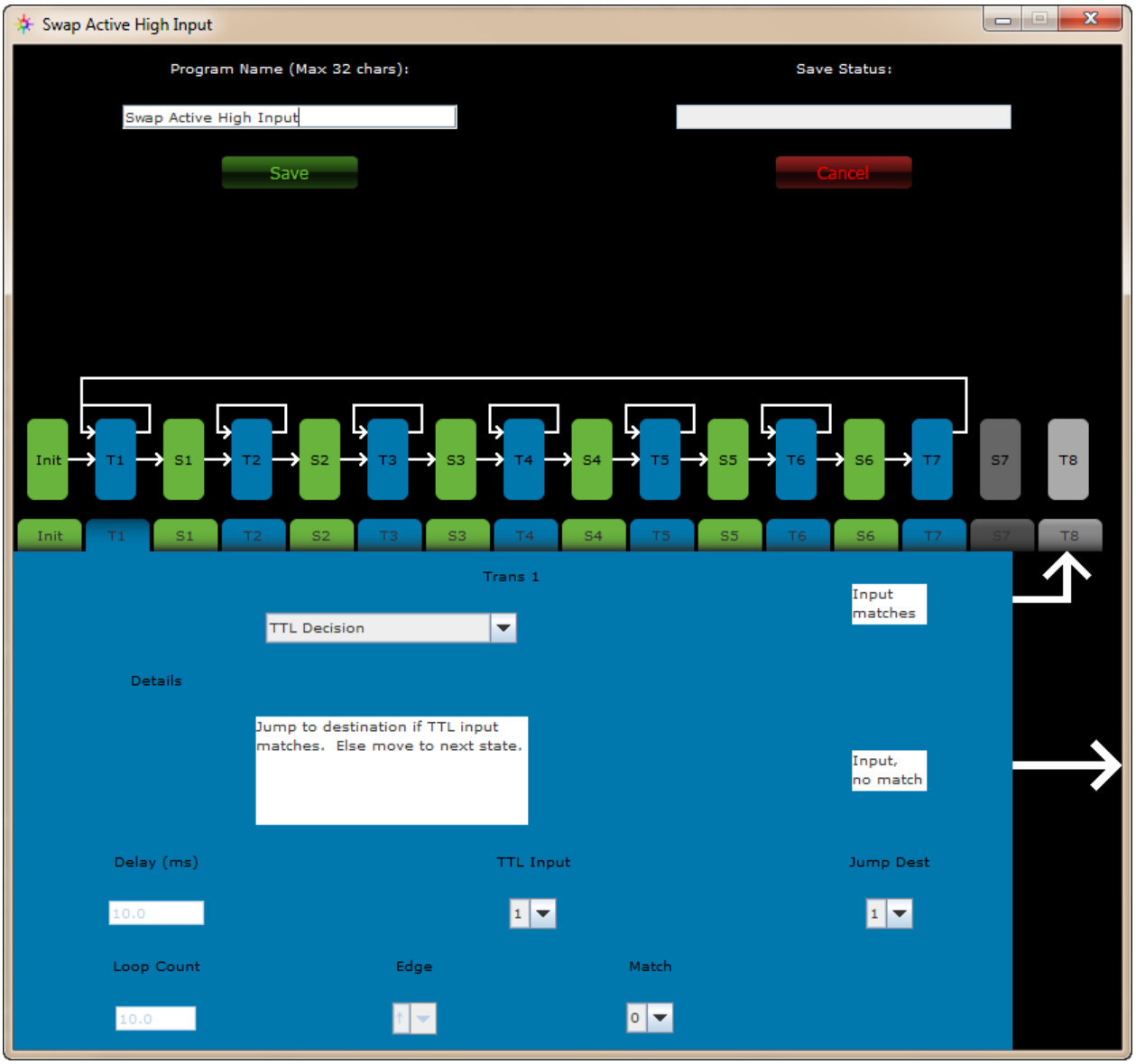


Figure 41 - Transition screen

There are 13 types of transitions available (Table 3), which are accessed from the *Trans* pull-down menu. Depending on the transition type utilized, it may be necessary to specify other variables such as a delay (*Delay* field), TTL input (*TTL Input* pull-down), or a jump destination (*Jump Dest* pull-down). All required fields will be active.

Transitions and their usage are described in Table 3.

Table 3 - Types of Transitions

Transition Type	Function	Variables which must be specified
Stop	Ends program	<NONE>
Configured, no processing	Proceed to the next state	<NONE>
Delay	Delay for a specified time before proceeding to the next state	Delay (milliseconds)
Jump	Proceed to a specified transition (the destination); analogous to a "go to" statement Destination may be another existing program	Jump Dest
Delay then Jump	Delay for a specified time and then proceed to a specified transition (the destination)	Delay (milliseconds) Jump Dest
TTL edge	Wait for a specified TTL edge and then proceed to the next state	TTL Input Edge Type
TTL edge, then delay	Wait for a specified TTL edge and then delay before proceeding to the next state	TTL Input Edge Type Delay (milliseconds)
TTL edge, then jump	Wait for a specified TTL edge and then jump to a specified transition (the destination)	TTL Input Edge Type Jump Dest
TTL edge, delay, then jump	Wait for a specified TTL edge, then delay for a specified time, and then jump to a specified transition (the destination)	TTL Input Edge Type Delay (milliseconds) Jump Dest
TTL decision	Compare TTL input to a specified value and either jump to a specified destination or proceed to the next state • if TTL input is the same as the match value, jump to the specified destination • if value is not the same, proceed to the next state • analogous to an "if, then" statement	TTL Input Match Jump Dest
Delay, then TTL decision	Delay a specified amount of time, then TTL decision as above	Delay (milliseconds) TTL Input Match Jump Dest
Loop	Lower a user specified count variable by 1, then check if the count has a value of zero • if the count value is equal to zero,	Loop Count Jump Dest

	proceed to the next state and return the count to its original value • otherwise, if the count value is non-zero, proceed to the jump destination • analogous to a “for loop”	
Delay, then Loop	Delay a specified amount of time, then loop as above	Delay (milliseconds) Loop Count Jump Dest

B. USING .TXT FILES TO CREATE PROGRAMS

Programs and Program Sets can also be created by writing text (.txt) files. The text file will contain a simple string of commands, with each command defining either the program name, Initial State, States, Transitions or Program End. Please see Appendix A (XIII.A) for information on the components of text files that specify programs.

C. EXAMPLE PROGRAMS

The CD included with the Heliophor and the HELIOPHOR SOFTWARE install contain sample programs which can be loaded using the File menu (see Section VII.A.1). The sample programs can be found in the file called “ExProgs.txt”. To demonstrate the use of states and transitions, four sample programs from the CD have been explored in detail in Appendix B (XIII.B). In each case, the details of programming using both the **Program** Tab of the HELIOPHOR SOFTWARE and a .txt file are shown.

IX. MAINTENANCE

Cleaning unit exterior

The exterior of the unit can be cleaned with a gentle, nonabrasive cleaner and cloth.

Cleaning interior optics

Interior optics should only be cleaned at the instruction of 89 North customer support or with the aid of a trained dealer.

Air intake and filter

Clean, clear air intake ports are required for efficient cooling of the unit. Remove any accumulated dust or debris on the air intake ports using a vacuum.

The air filter must be cleaned regularly, but frequency depends on the operating environment. Inspect the filter monthly and clean whenever dirt or dust is apparent. To access the filter, unplug the main unit and rotate it so the user accessible side is facing upwards. Remove the 7 screws holding the cover in place. Remove the cover and set aside. Pull the filter out, inspect it, and clean if necessary. This is done by simply vacuuming the surface of the filter mesh.

Firmware upgrades

The latest firmware versions for the main unit, hand controller, and modules are all available on the 89 North website, www.89north.com. To update the Heliophor firmware, follow the following steps:

1. Power on the Heliophor, and attach the Heliophor to the computer using the USB cable.
2. Run HeliophorUpgrade.msi or HeliophorUpgrade.x64.msi for 32-bit or 64-bit computers, respectively.
    a. On XP machines, simply run the program.
    b. On later operating systems, right click and select <run as administrator>
3. In the application, choose Port->COMx, where COMx is the virtual COM port for the Heliophor.
4. Click Start. The upgrade will proceed.

During the system reset that occurs during upgrade, the hand controller may display a “Power Supply Fail” error. This is normal and may be disregarded.

X. ERROR CODES, WARNINGS, OVERRIDES

Error and Warning Codes

If problems are encountered while using the Heliophor, first check for error or warning messages displayed in the upper right corner of the hand controller screen. On the hand controller screen, the top right hand corner displays messages associated with the hand controller (lower line) and system level messages (upper line).

If no message appears on the hand controller, open the Status tab on the HELIOPHOR SOFTWARE. Error and warning messages appear on both the hand controller and the HELIOPHOR SOFTWARE. Within the HELIOPHOR SOFTWARE, messages are reported on the Status tab.

In many cases, cycling the system power will be helpful in resolving errors. To cycle the system power, use the rocker switch (on the rear of the unit) to turn off the main unit. Leave the unit off for a full 30 seconds, and then turn the system back on.

Error and warning messages can be cleared by pressing the DIM button on the hand controller or by using the “Clear Warn” option in the File menu of the HELIOPHOR SOFTWARE.

The Heliophor’s error and warning messages are listed in the table below. The severity of the message is also noted; some messages represent fatal errors, some may be overridden, and some are informational only. The lights on the upper right of the hand controller and on the upper front right of the main unit similarly indicate the severity of error messages:

- A red light indicates a fatal error, which will prevent operation of the system.
- A yellow light indicates a warning, which may prevent operation of some components or optimal function.
- A green light indicates that operation is normal. A flashing green light indicates that the unit is in standby mode.

Table 4 - Errors and Warnings

Message displayed on Hand Controller	*Message displayed on HELIOPHOR SOFTWARE*	*Source of error*	*Possible resolution*	*Severity of Error*
The following messages pertain to the hand controller/hand controller status field				
	No Handcontrol (Displayed as hand control status)	No hand controller installed	Plug in hand controller	Information only: Hand control will be suspended, but system can still be controlled by HELIOPHOR SOFTWARE
No Comms		Hand controller not communicating	This error appears during initialization	Information only: Communication with hand controller should resume following initialization
Comm Error		Hand controller cannot communicate with main unit	Unplug and plug the hand controller back in, cycle system power; contact 89 North if error persists	Warning only: Hand control will be suspended, but system can still be controlled by HELIOPHOR SOFTWARE
Button Fail Lo	Button Fail Low	Hand controller button not operating correctly	Hand controller must be replaced; contact 89 North	Warning only: Hand control will be suspended, but system can still be controlled by HELIOPHOR SOFTWARE
Button Fail Hi	Button Fail High	Hand controller button not operating correctly	Hand controller must be replaced; contact 89 North	Warning only: Hand control will be suspended, but system can still be controlled by HELIOPHOR SOFTWARE
No Cal Board	No Cal Port	Failed to establish communication with the calibration port	Unplug and plug the hand controller back in, cycle system power; contact 89 North if error persists	Warning only: Hand control will be suspended and calibration not possible, but system can still be controlled by HELIOPHOR SOFTWARE

Message displayed on Hand Controller	*Message displayed on HELIOPHOR SOFTWARE*	*Source of error*	*Possible resolution*	*Severity of Error*
The following messages pertain to the main system/main controller status field				
PSupply Fail	PSupply Fail	Monitored power supply voltages outside acceptable range	This error may appear during normal shut down; if error persists, cycle power, then call 89 North if no resolution	Fatal Error: No system function
(none)	Low Power Mode	System in standby mode	Use the standby power button on the front of the Heliophor or the “ON/OFF” button on the hand controller to exit standby mode	Informational only: System will operate normally once removed from standby mode
Acc Panel Open	Access Panel Open	The side panel of the unit is removed or the interlock switch that detects the presence of the side panel has malfunctioned	Ensure panel is firmly in place with screws tight and then restart the system; if error persists call 89 North	Error: All modules are disabled until a light guide is detected
Cal, >20% Chng	Cal Fail, >20% Change	Calibration failure due to large change between current and most recent calibration.	Ensure light guide is correct size and properly seated, ensure correct dichroics and trim filters are installed; if error persists contact 89 North	Warning only: System will function, but intensities of modules may be incorrect
No Light guide	No Light guide	Interlock detects no light guide present or interlock switch has failed	Ensure light guide is properly seated; contact 89 North if error persists	Fatal Error: No system function
LLG In HandCtl	LLG in Hand Ctl Warn	LLG is detected in the calibration slot	Remove light guide from hand controller and place into the microscope adapter	Warning only: System cannot be used to deliver light to microscope until LLG is repositioned

Message displayed on Hand Controller	*Message displayed on HELIOPHOR SOFTWARE*	*Source of error*	*Possible resolution*	*Severity of Error*
Cal, No Slot	Cal, No Slot Available	No additional configuration data can be store by the system	Contact 89 North for assistance	Warning only: System will function, but module performance may be suboptimal
	Comm Error	The HELIOPHOR SOFTWARE cannot communicate with the main unit	Cycle power and contact 89 North if error persists	
Cal, No Light	Cal Fail, No Light	Calibration failure because no light was detected on the sensor	Ensure light guide is plugged into hand controller and properly seated in both hand controller and Heliophor main unit; verify dichroics are in correct position if unit configuration has recently changed. Cycle power and contact 89 North if error persists	Warning only: System will function, but intensities of modules may be incorrect
Cal, >5% Chng	Cal, >5% Change	Calibration has changed more than 5% since the most recent calibration	Ensure light guide is correct size and properly seated, ensure correct dichroics and trim filters are installed; if error persists contact 89 North	Warning only: System will function, but intensities of modules may be incorrect
Cal, Filt Fail	Cal Fail, Missing Mod	Dichroics or other internal optics are missing or incorrectly installed	Check that dichroics and modules are properly installed and seated; contact 89 North if error persists	Warning only: System will function, but intensities of modules may be incorrect

Message displayed on Hand Controller	*Message displayed on HELIOPHOR SOFTWARE*	*Source of error*	*Possible resolution*	*Severity of Error*
Cal,Other Warn	Cal, Other Warns Exist	Calibration aborted due to another warning that must be addressed before a calibration is possible	Address other warning before proceeding with calibration	Warning only: System will function, but intensities of modules may be incorrect
Cal Worked	Calibration Good	Calibration successful		Informational only
Request Reset	Request Reset	This message appears after a reset request has been made through the HELIOPHOR SOFTWARE		Informational only
The following messages pertain to one or more modules/main controller status field				
Two Mods Same	Two modules Same	Two identical modules are installed in the unit	Remove the duplicate module	Fatal Error: No system function
Module Pos Error	Module Pos Error	Modules have been installed in the incorrect position order	Modules must be installed in position order 1,2,3 from shortest to longest wavelengths; rearrange modules into this order	Fatal Error: No system function
Mod Pos Empty	Mod Pos Empty	Modules have been installed with an empty slot between modules	Rearrange modules such that positions 1, 2, 3, etc are filled in order	Fatal Error: No system function
5 or 6 Mods On	Too Many Mods On	Five or more modules are currently powered on	Use the hand controller or HELIOPHOR SOFTWARE to turn off one or more modules; a maximum of 4 modules can be simultaneously powered on	Fatal Error: System will not function with more than 4 modules powered

Message displayed on Hand Controller	*Message displayed on HELIOPHOR SOFTWARE*	*Source of error*	*Possible resolution*	*Severity of Error*
Module Err	Module Fail	One of the modules is malfunctioning	The malfunctioning module can be identified using the Status tab on the HELIOPHOR SOFTWARE; record any error messages and cycle the power; if error persists contact 89 North	Fatal Error: No system function
Mod Incompat	Modules Incompatible	Two modules are installed that cannot be used simultaneously	Consult the module compatibility chart (see Section Vb) and remove one of the offending modules	Fatal Error: No system function
Spect Overlap	Mod Spect Overlap	Modules present are not optimal for simultaneous use due to spectral overlap.	Refer to module compatibility chart; re-install modules in a compatible configuration or override this error as described above (use DIM button or “Clear Warnings” in File menu of HELIOPHOR SOFTWARE)	Warning only: System will function, but module performance may be suboptimal

Message displayed on Hand Controller	*Message displayed on HELIOPHOR SOFTWARE*	*Source of error*	*Possible resolution*	*Severity of Error*
Mod on >15 min	Module on > 15 min	One or more modules have been powered on for longer than 15 minutes	System will turn off any modules that have been powered on for more than 15 minutes; if the user desires the module to be powered for longer than 15 minutes, override the error (use DIM button or “Clear Warnings” in File menu of HELIOPHOR SOFTWARE) and use the HELIOPHOR SOFTWARE or the hand controller to allow continuous operation	Warning only: System function will continue, but modules will be powered off, unless continuous operation is enabled
Mod not Recog	Mod not Recognized	A new module has been installed without firmware upgrade	Upgrade the firmware for the main controller and the modules	Warning only: The affected module cannot be powered, but the system will function
	Not Installed	This appears in the module status window and indicates no module installed		Informational only
	Virtual Module	This appears in all the module status windows when no modules are installed		Informational only
	Module In Boot	This appears in all the module status windows during firmware updating		Informational only
	Mod Overcurrent	Module current has surpassed the level in the protection circuit	Record error; cycle power and contact 89 North if error persists	Fatal Error: No system function

Message displayed on Hand Controller	*Message displayed on HELIOPHOR SOFTWARE*	*Source of error*	*Possible resolution*	*Severity of Error*
	Mod Therm Open	Module temperature monitoring is not working	Record error; cycle power and contact 89 North if error persists	Fatal Error: No system function
	Fwd Volt Err	Voltage inside the module has exceeded its limit	Record error; cycle power and contact 89 North if error persists	Fatal Error: No system function
	I2C Not Idle	Communication error	Record error; cycle power and contact 89 North if error persists	Fatal Error: No system function
	TEC Therm Open	Phosphor temperature monitoring is not working	Record error; cycle power and contact 89 North if error persists	Fatal Error: No system function
	Bad Prod ID	Product ID on module does not match known product IDs	Record error; contact 89 North if error persists	Fatal Error: No system function
	Phosphor Temp Warn	Phosphor temperature has exceeded safe usage limit	Record error; verify that airflow path is clear, check air filter, cycle power and contact 89 North if error persists	Fatal Error: No system function
	Overtemp Warn	Module temperature has exceeded safe operating limit	Record error; verify that airflow path is clear, check air filter, cycle power and contact 89 North if error persists	Fatal Error: No system function

XI. TROUBLESHOOTING

Many problems with the system can be identified by the error or warning codes that are produced (see Table 5). In certain cases, however, it will not be possible to view a message or none will be produced. In such instances, the troubleshooting table shown below will be helpful in identifying the causes of poor function.

Table 5 - Troubleshooting

Symptom	*Possible causes*	*Possible solutions*
Light engine does not turn on	System is not plugged in	Check that power cord is securely plugged into the main unit and the power outlet
	Rocker switch is in OFF position	Turn rocker switch to ON position
	Outlet not powered	Check power to outlet using volt meter or plug in another electric device
	System is in standby mode (the error indicator light will flash green in this state)	Press the soft power button on the front of the unit or the ON/OFF button on the hand controller
Little or no light out of end of light guide	Light Guide not fully seated in light engine	Confirm the light guide is seated, then attempt recalibration
	System in standby mode	Press the soft power button on the front of the unit or the ON/OFF button on the hand controller
	Liquid guide bent beyond acceptable bend radius	Light guide must be replaced; contact 89 North to order a new liquid light guide
	Incorrect dichroic installed in system	Access dichroics and ensure the correct dichroics are properly installed
	Incorrect trim filter installed in system	Access trim filters and ensure the correct trim filters are properly installed

Little or no light out of microscope objective	Incorrect filter cube in microscope	Verify that the correct filter cube is installed in the microscope
	Microscope shutter, field stop, or aperture stop closed	Check microscope
	Microscope adapter incorrectly aligned	Check microscope
	No light coming through light guide	Check to see if light is coming from end of light guide by shining onto a piece of paper; if no light apparent, refer to “Little or no light out of end of light guide” above
System shutting down during use	Inadequate air flow	Ensure there is at least 6” of clearance around the unit (more if heat producing equipment is in the proximity), check and clean air filter
	Default shut down occurred following 15 minutes of module running continuously	Choose “Clear Warn” in the File menu of the HELIOPHOR SOFTWARE or push the DIM button on the hand controller; to avoid a recurrence, select “Allow continuous” from the File menu of the HELIOPHOR SOFTWARE or choose option 5 from the Input menu on the hand controller
	Module failure	Refer to error codes on hand controller or HELIOPHOR SOFTWARE; contact 89 North
An individual module won’t power on	Four modules already on	Select only the four modules that need to be powered on
	Module incorrectly installed	Check for any error messages; access modules and ensure the non-working module is correctly installed
System does not respond to hand control button presses	System in analog mode	Change operating mode to Basic mode
	Program already running	Stop the program using either the hand controller or the HELIOPHOR SOFTWARE or simply wait until the program has concluded; hand controller will function normally as soon as the program completes
	Hand controller unplugged from main unit	Ensure hand controller is properly connected to main unit

System does not respond to external TTLs or analog voltage	External signal source disconnected from system	Verify that all cables are securely attached and correctly installed
	Incorrect program running	Verify the program is correct; open the program in edit mode and ensure the correct channel is utilized by the program
	System not in correct TTL mode	Refer to the Advanced tab in the HELIOPHOR SOFTWARE and ensure the correct mode is selected
No power on hand controller unit	Hand controller unplugged from main unit	Ensure hand controller cable is securely attached
	Main unit not powered on	Ensure main unit is plugged in and powered ON (check rocker switch and ensure the system is not in standby mode)
	Hand controller in DIM mode	Press DIM button on hand controller to exit DIM mode

XII. WARRANTY INFORMATION

Warranty

The Heliophor main unit and hand control are under warranty for two (2) years from the date of delivery. Each module is under a limited lifetime warranty: limited to the original user and non-transferable. The warranty extends to a main unit, hand control, or module which has proved defective and has failed through normal use, but excludes and does not cover any light engine chassis, hand control, or module which has been damaged, disassembled, modified, misused, repaired or reworked, or improperly handled.

89 North will, at its option, either replace or repair any warranted main unit, hand control, or module that is defective. Any main unit, hand control, or module repaired or replaced under warranty is only warranted for the period of time remaining in the original warranty. 89 North reserves the right, at its sole option, to issue a credit as an alternative to repair or replacement. These warranties are non-transferable.

89 North's liability is expressly limited to the replacement cost of the main unit, hand control, or module, as the case may be.

EXCEPT FOR THE WARRANTIES STATED HEREIN, NO WARRANTY, CONDITION OR REPRESENTATION, EXPRESS, IMPLIED, ORAL OR STATUTORY, IS PROVIDED, INCLUDING, WITHOUT LIMITATION, ANY WARRANTY, CONDITION OR REPRESENTATION OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. 89 NORTH SHALL NOT BE LIABLE FOR ANY SPECIAL, CONSEQUENTIAL, INCIDENTAL, EXEMPLARY OR INDIRECT COSTS OR DAMAGES, INCLUDING WITHOUT LIMITATION, LITIGATION COSTS, INSTALLATION AND REMOVAL COSTS, LOSS OF DATA, PRODUCTION OR PROFIT ARISING FROM ANY CAUSE WHATSOEVER, REGARDLESS OF THE FORM OF THE ACTION, WHETHER IN CONTRACT, TORT (INCLUDING NEGLIGENCE), STRICT LIABILITY OR OTHERWISE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH COSTS OR DAMAGES.

Return Material Authorization Procedures

89 North will only accept products returned under its Return Material Authorization process ("RMA"). A customer shall obtain a RMA number from 89 North prior to returning any product and return the product prepaid and insured to 89 North. If any product is returned without an expressed reason for return, 89 North will not evaluate

the product but will return it to the customer at the customer's expense. Any product repaired or replaced by 89 North will be sent to the customer at 89 North's expense.

If a returned product is not under warranty, 89 North will evaluate the product and provide a quote to the customer. 89 North will assess a minimum charge of 2 hours time at the current service rate for all evaluations. The evaluation charge will be credited against any repair or replacement authorized by the customer. If the customer does not authorize the repair, the product will be returned to the customer at the customer's expense.

Contact information/ Technical Support

Telephone: 1.877.417.8313 or +1.802.882.0302

Email: support@89north.com

Web: www.89north.com

US Mailing address: 1 Mill St. Unit 285, Burlington, VT 05401

XIII. APPENDICES

A. COMPONENTS OF TEXT FILES USED TO SPECIFY PROGRAMS

1. PROGRAM # (1-8)

a. Command: PN{1-8}

b. The program new command configures a program that was previously not configured

2. PROGRAM NAME

a. Command: PT{1-8}{program title ending with \r}

b. The program title command sets the title for a program. Program titles can be up to 31 characters in length, but should not contain any backslashes (\) or (>) symbols.

3. INITIAL STATE

a. Command: CI[L{1-6}{[+,-][{I}10-100]}][[T{1-6}{0,1}]|TA{000000-111111}]

b. The configure initial command modifies the initial state. Any or all of the LEDs can change intensity, or be turned on or off. Single TTL outputs can be configured, or all of them can be set using the TA option.

c. Examples:
   i. “CIL5I100\r”, configure the initial state of LED 5 to 100% intensity. Note: This command does not change if the LED is currently off or on.
   ii. “CIL3+\r”, configure the initial state of LED 3 to be on. Note: This command does not change if the LED intensity.
   iii. “CIL2+I47\r”, configure the initial state of LED 2 to be on with 47% intensity.
   iv. “CITA011110\r”, configure the initial state of the TTL outputs to TTL out 1, and 6 off, while the rest of active high.
   v. “CIT50\r”, configure the initial state of TTL output 5 to off. The rest of the TTL outputs are unchanged.
   vi. “CIL5-I30L2+I22L4I47T20T41\r”, configure LED5 to be off with an intensity of 30%, LED2 on with an intensity of 22%, and LED4 to an intensity of 47% (no change to if it is on or off), TTL output 2 to off, and TTL output 4 to on.

4. STATES (UP TO 7)

a. Command: CS{1-7}[L{1-6}{[+,-][{I}10-100]}][[T{1-6}{0,1}]|TA{000000- 111111}

b. The configure state command modifies a currently configured state, or configures a state that was previously not configured. Any or all of the LEDs can change intensity, or be turned on or off. Single TTL outputs can be configured, or all of them can be set using the TA option

c. Example:
   i. “CS3L2-I82L5+47TA011001\r”, configure state 3 so that LED 2 is off but at 82% intensity, LED 5 is on at 47% intensity, and TTL output 2, 3, and 6 are active high.

5. TRANSITIONS (UP TO 8)

a. Command: CT{1-8}[D{10-10000000}][J{1-8}][I{1-6}{R,F,E}][T{1- 6}{0,1}][C{2-100}]

b. The configure transition command modifies a currently configured transition, or configures a transition that was previously not configured.
   i. Transitions can wait for rising/falling/either edge of a TTL input signal.
   ii. A transition can delay for 10µsec to 10s.
   iii. A transition can always jump to a transition, jump based on a TTL input, or jump based on an internal counter.
   iv. A transition contains an internal counter so the transition can be repeated multiple times. When the count is zero, the transition will move to the next higher numbered state.
   v. Some transition features can be combined including wait for TTL input then delay, delay then jump, and delay then jump based on a TTL input.
   vi. The count feature can only be used in transitions that contain a jump command. When the transition is entered the count is decremented. If the count is nonzero, the jump is followed to a transition. If the count is zero, the count is reloaded to the original value, and then execution moves to the next state. This allows sequences to be repeated multiple times.
   vii. If a delay and jump are combined, the program waits for the delay, and then performs the jump.
   viii. If the transition contains a delay, count, and jump, the program first waits for the delay time. It then decrements the transition counter. If the result is non-zero, the jump is followed. If the result is zero, the execution moves to the next state.
   ix. If the jump contains a TTL input, the jump is followed if the TTL input matches the configured value. Otherwise, the transition goes to the next state.

c. Examples:
   i. “CT3D10000\r”, configure transition 3 to delay for 10 msec before moving to state 3.
   ii. “CT5J3\r”, configure transition 5 to immediately jump to transition 3.
   iii. “CT2I5R\r”, configure transition 2 to wait for a rising edge of TTL input 5, and then move to the next state (state 2).
   iv. “CT4J1C035\r”, configure transition 4 to decrement starting at a count of 35. If the result is non-zero, jump to transition 1. If the result is zero, move to the next state (state 4).
   v. “CT8D1000C047J4\r”, configure transition 8 to upon entry delay for 1 ms. Next decrement the internal counter which starts at 47. If the result is non-zero, jump to transition 4. If the result is zero, end the program. (Note: The program ends because there is no state 8).
   vi. “CT5D2500J2T30\r”, configure transition 5 to upon entry delay for 2.5 ms. Next TTL 3 is read. If the input is low, the program jumps to transition 2. Otherwise, the program continues to the next state (state 5).

B. EXAMPLE PROGRAMS

1. PROGRAM 1: “SWAP ON ACTIVE HIGH”

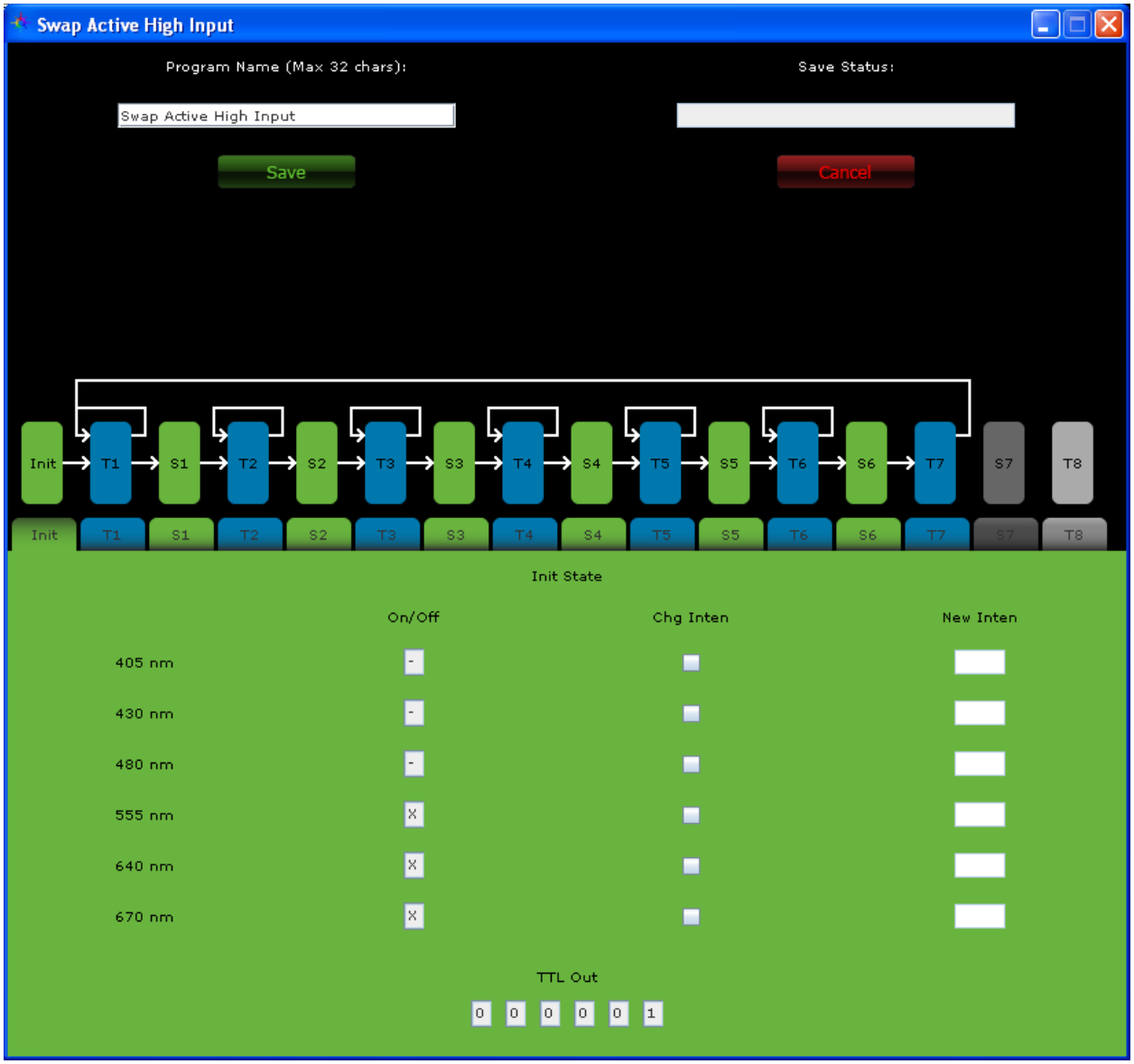
The objective of this program is to utilize a TTL signal from another system component to trigger three modules to turn on and off in sequence. Such a program could be utilized to allow sequential three color imaging. In such an example, a TTL signal from the camera would trigger the module to come on before it captured an image and turn off once the image had been captured. This program demonstrates the use of the following transitions:

- TTL Decision
- Jump

a. Program Tab Implementation

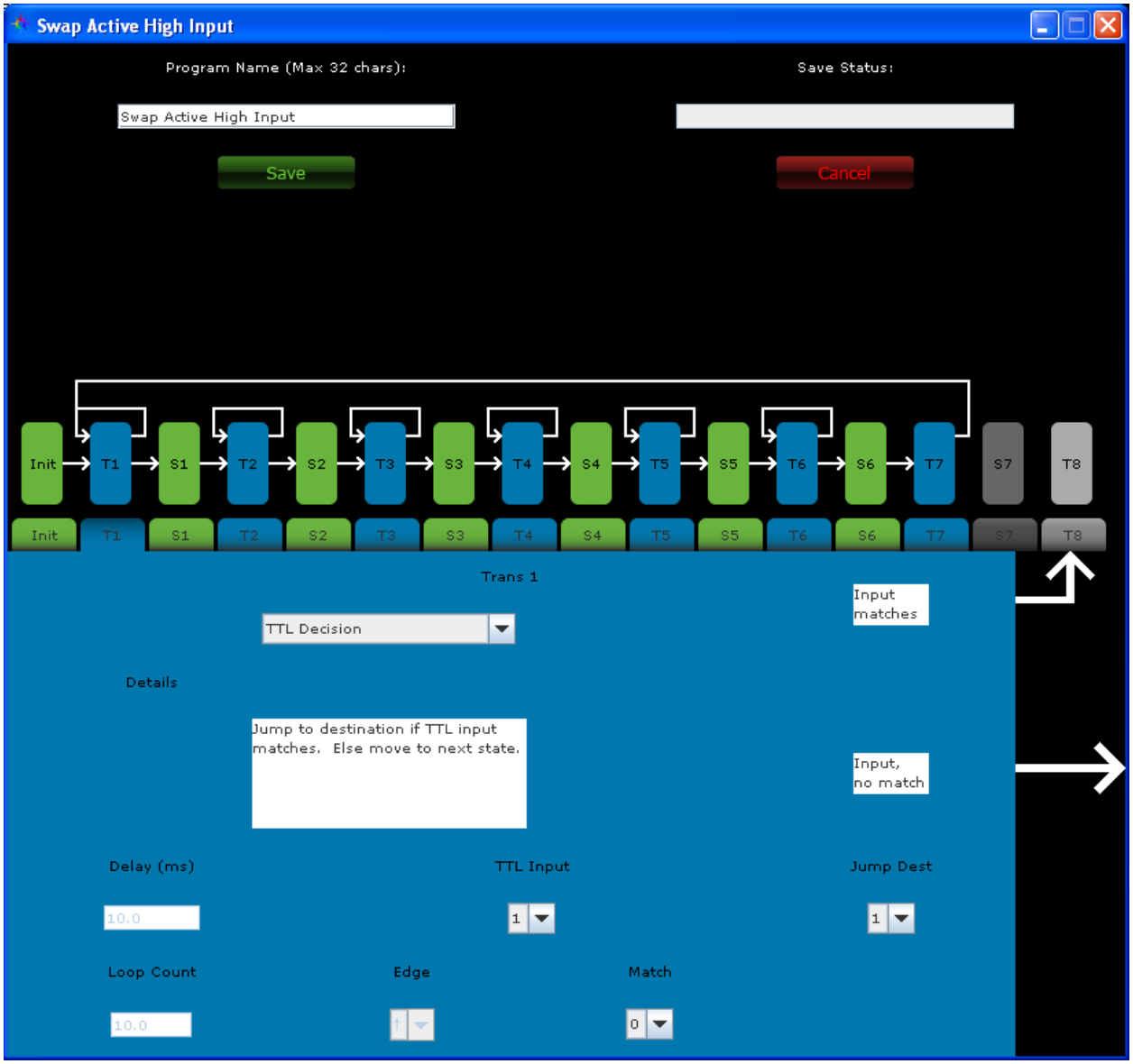
In the initial state of this program, all modules are powered off.

Initial State:



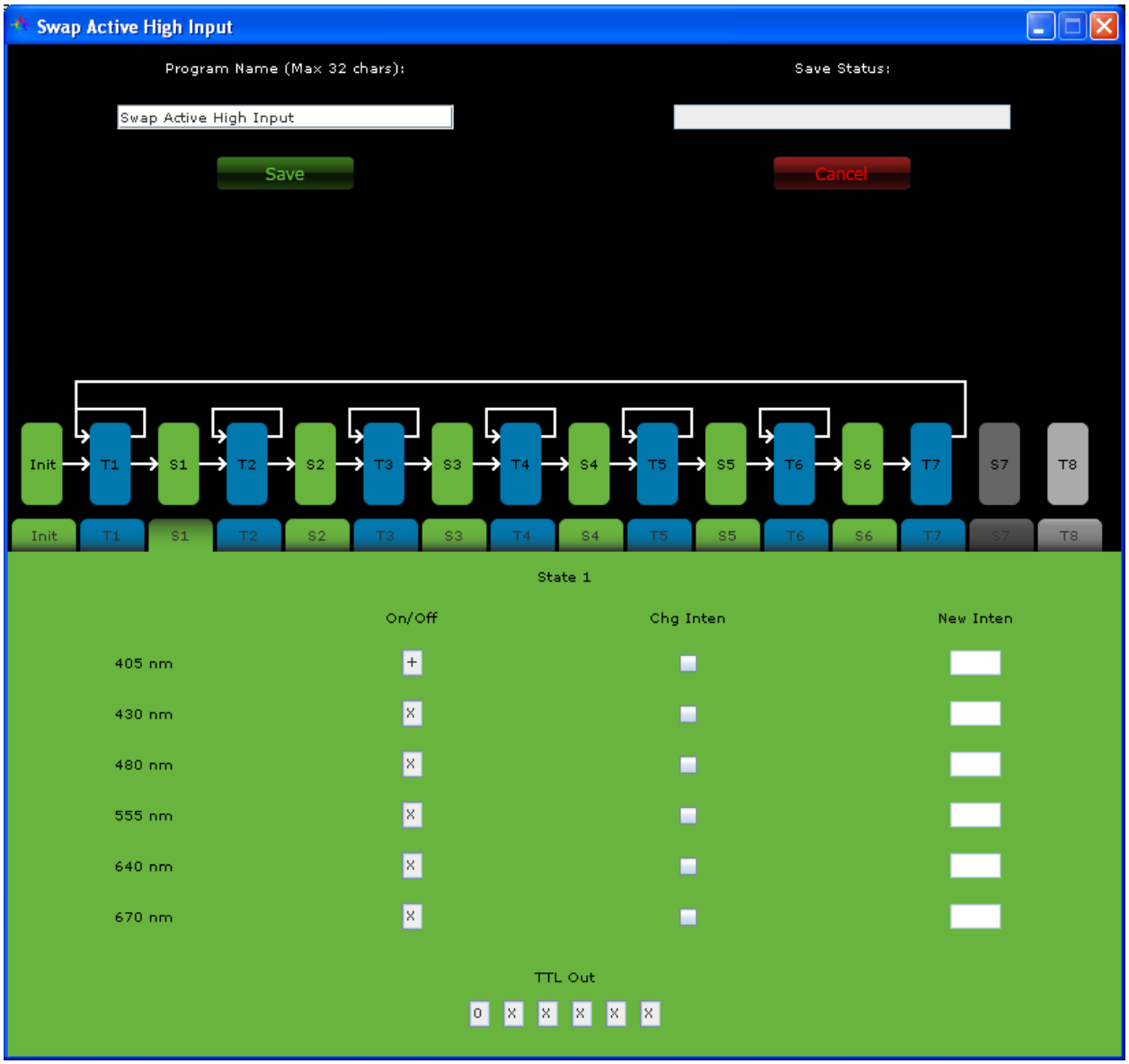
The first transition, T1, contains a TTL Decision; this indicates the Heliophor will monitor the TTL input for a match. When a match is present, it will jump to the specified destination. When no match is present, it will simply proceed to the next state. Note that in this example, TTL input channel 1 is utilized, the jump destination is transition 1 (T1) and the match value is zero. This means that as long as TTL input 1 is low (0), the program will stay in transition 1 (T1), monitoring the value and doing nothing. However, once the value of TTL input 1 changes, the program will proceed to the state 1 (S1). This TTL Decision creates a loop that is made visually apparent by the white arrow circling over T1 in the diagram.

Transition 1:



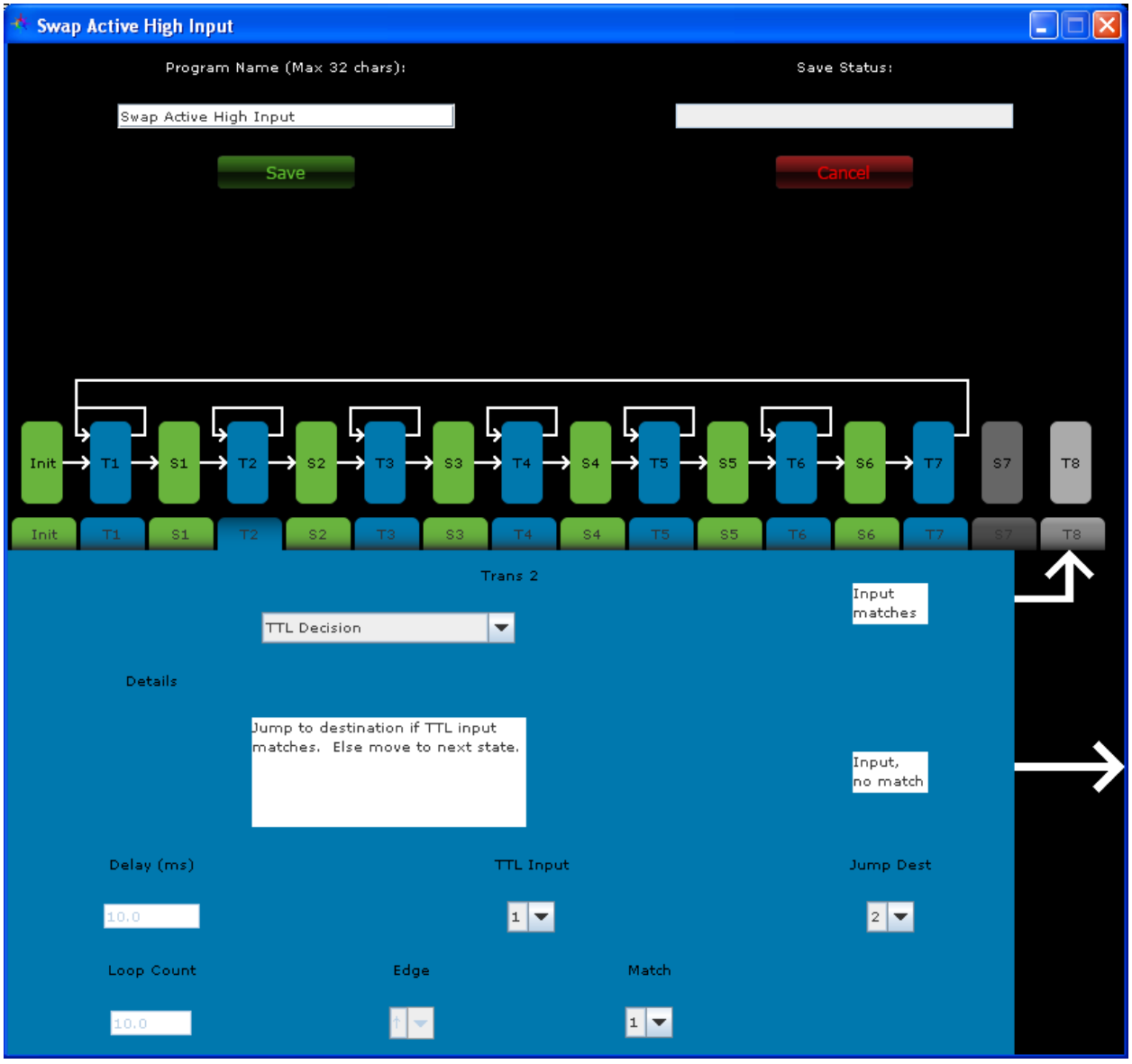
The next state, S1, is only reached when TTL input channel 1 is a high value. At this point, the first module is turned on (note the plus sign in box). All other modules remain unchanged.

State 1:



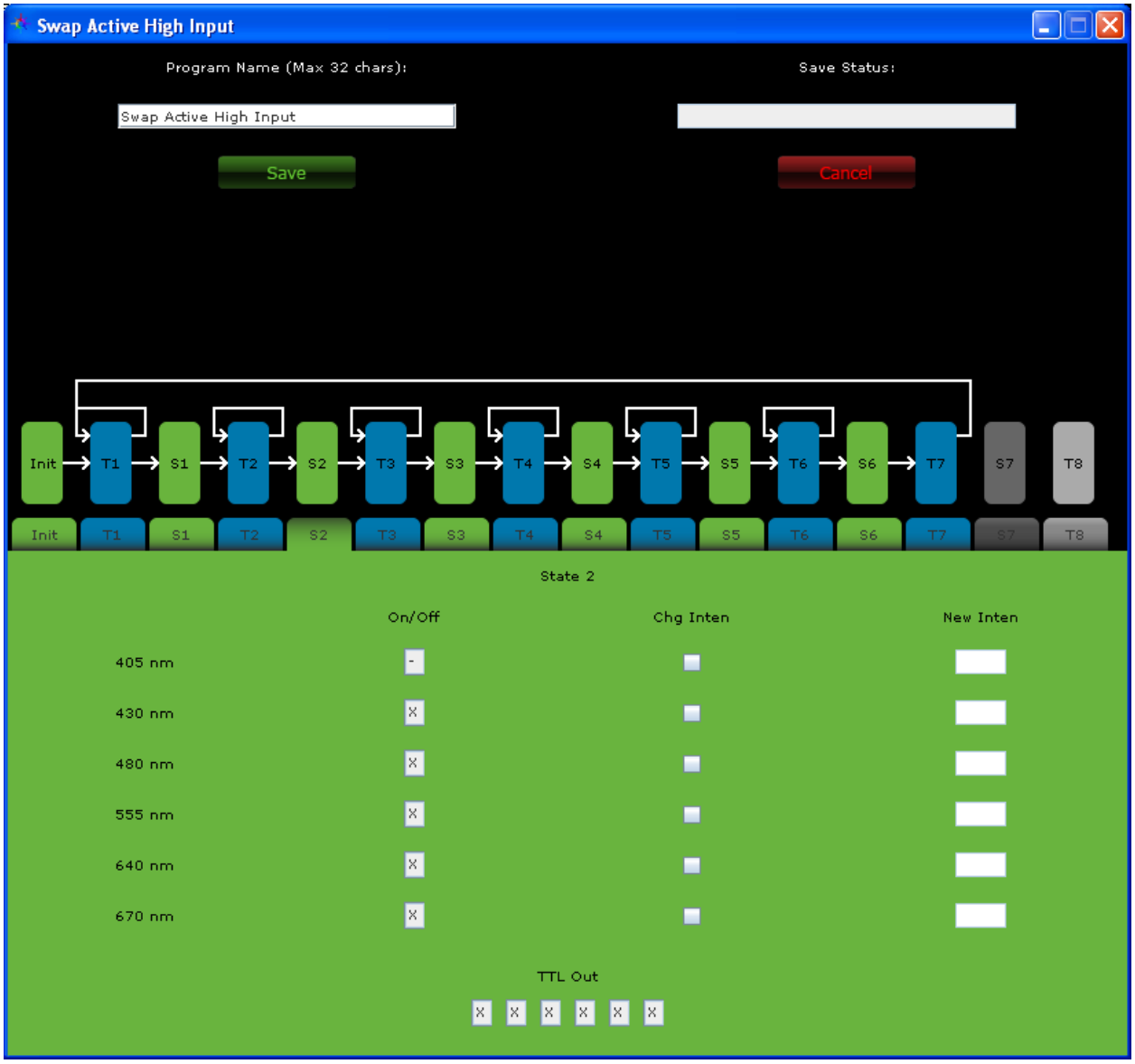
In the next transition, T2, the program is again looking at the value of TTL channel 1. However, this time, the match value is set to 1. As before, we are establishing a loop, but this time the loop is around T2. When a value not equal to 1 is obtained, the program will proceed to the next state.

Transition 2:



In S2, the first module is turned off.

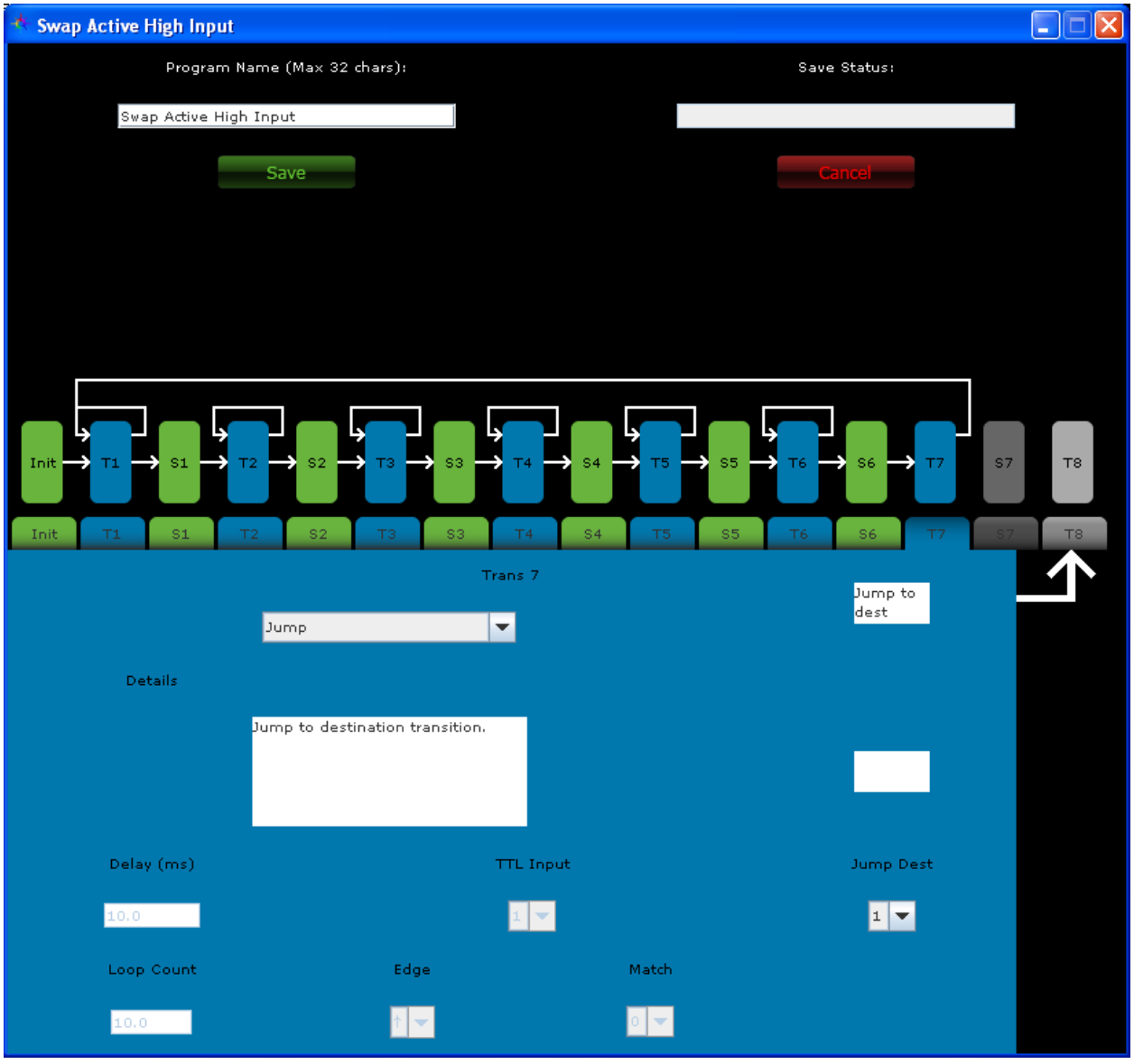
State 2:



Taken together, this means that T1 “looks for” an active high TTL input on channel1 before allowing the first module to be powered on in S1. Then T2 “looks for” an active low TTL input on channel 1 before allowing the first module to be powered off in S2.

This pattern continues up until T7, which is a jump back to T1. As the white arrows indicate, this forms a loop that ensures the program continues running until it is stopped by the user. Note that these arrows can assist the user when trying to understand or create a program by making the flow of the program readily apparent.

Transition 7:



b. Text File Implementation

pn1
ptSwap Active High Input
cil1-l2-l3-ta000001
ct1j1t10
cs1l1+t10
ct2j2t11
cs2l1-
ct3j3t10
cs3l2+
ct4j4t11
cs4l2-
ct5j5t10
cs5l3+
ct6j6t11
cs6l3-t11
ct7j1
pe

2. PROGRAM 2: “RISING EDGE, DELAY, THEN SEQUENCE”

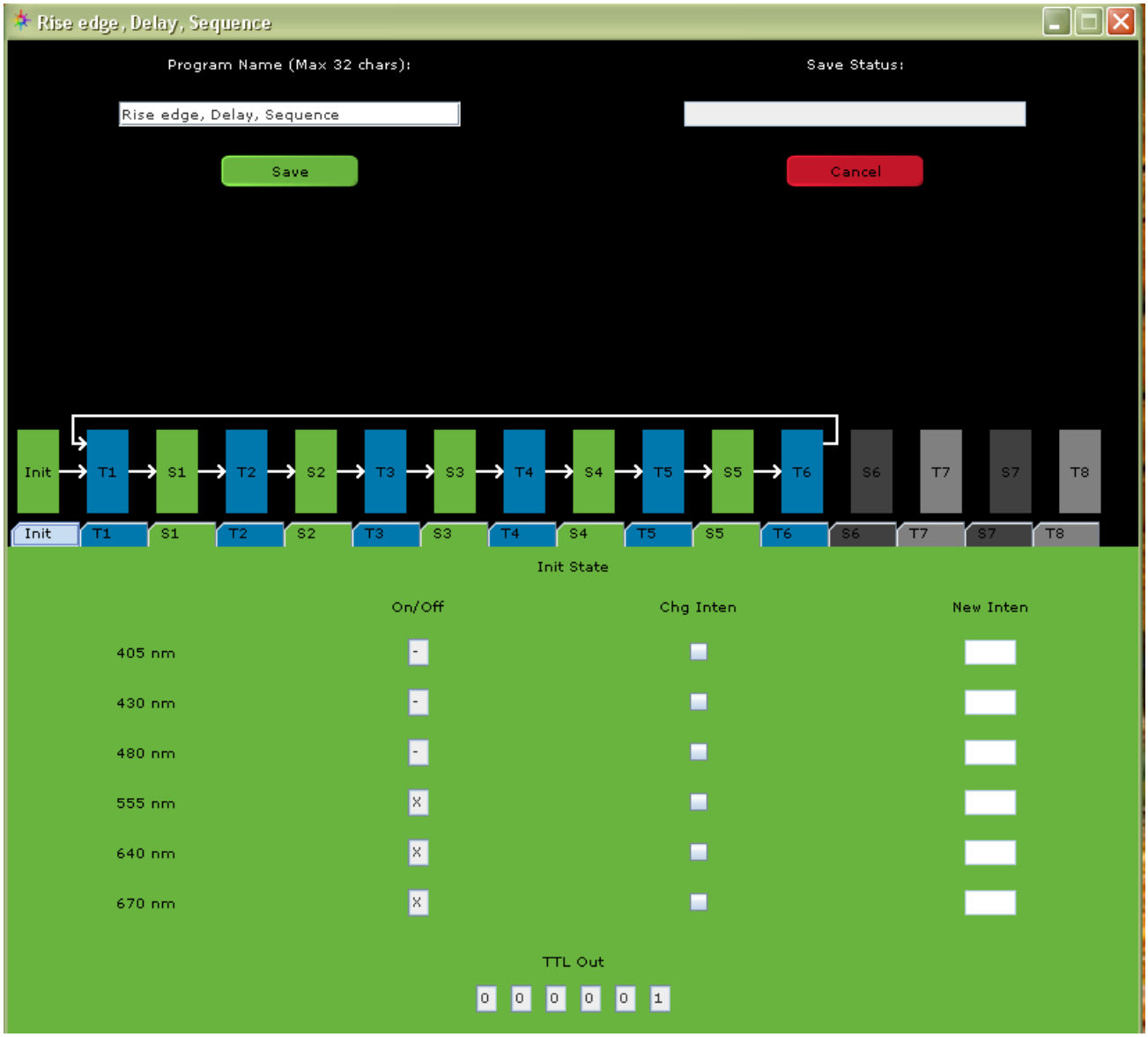
The objective of this program is to utilize a signal from another instrument to turn the first three modules on and off in sequence. Specifically, a rising edge on a TTL channel must be obtained and then a brief delay will be implemented. This program could be used in combination with an instrument with a known delay. For example, if a stage controller requires a small amount of time to actually move the stage, this program would detect the stage move event, wait until the move is complete, and then begin turning on the modules to allow image capture. This program demonstrates the use of the following transitions:

- TTL Edge, then Delay
- Jump
- Delay

a. Program Tab Implementation

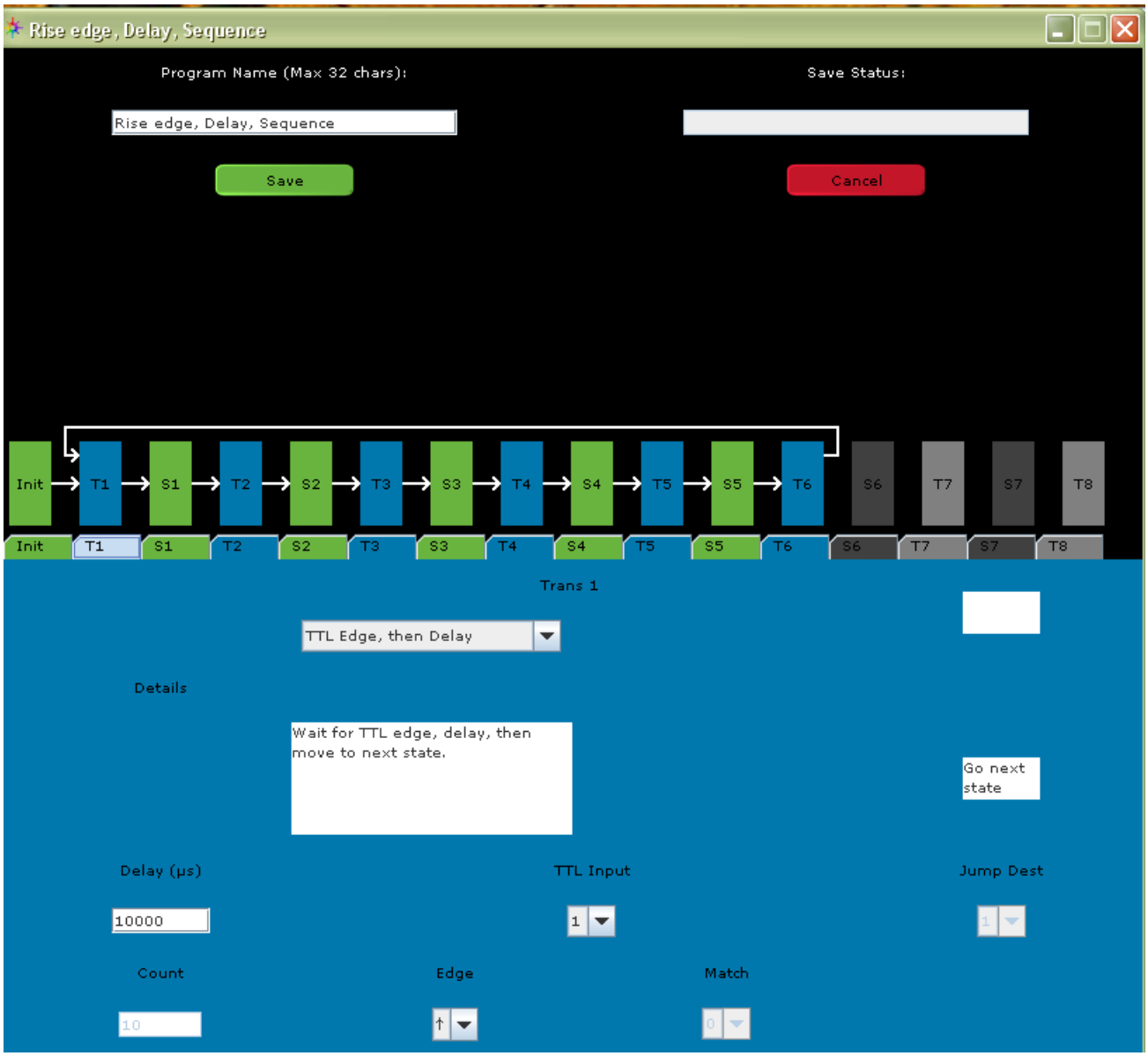
In the initial state, none of the modules are powered.

Initial State:



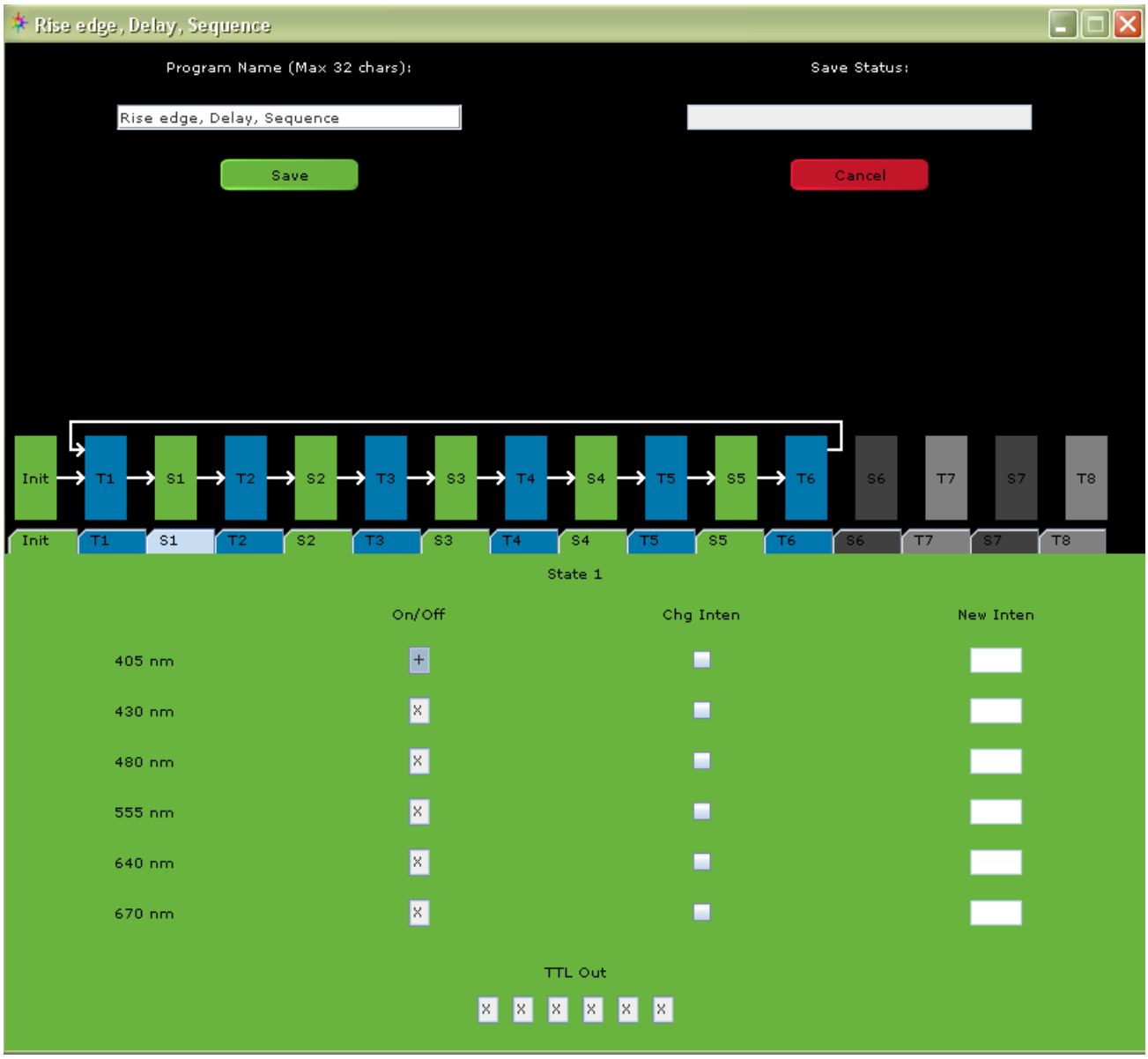
In the first transition, the unit looks for a TTL edge. Note that TTL input channel 1 is utilized and that a rising edge has been specified. Once the TTL edge is seen, the unit will delay for 10.0 milliseconds and then proceed to the next state.

Transition 1:



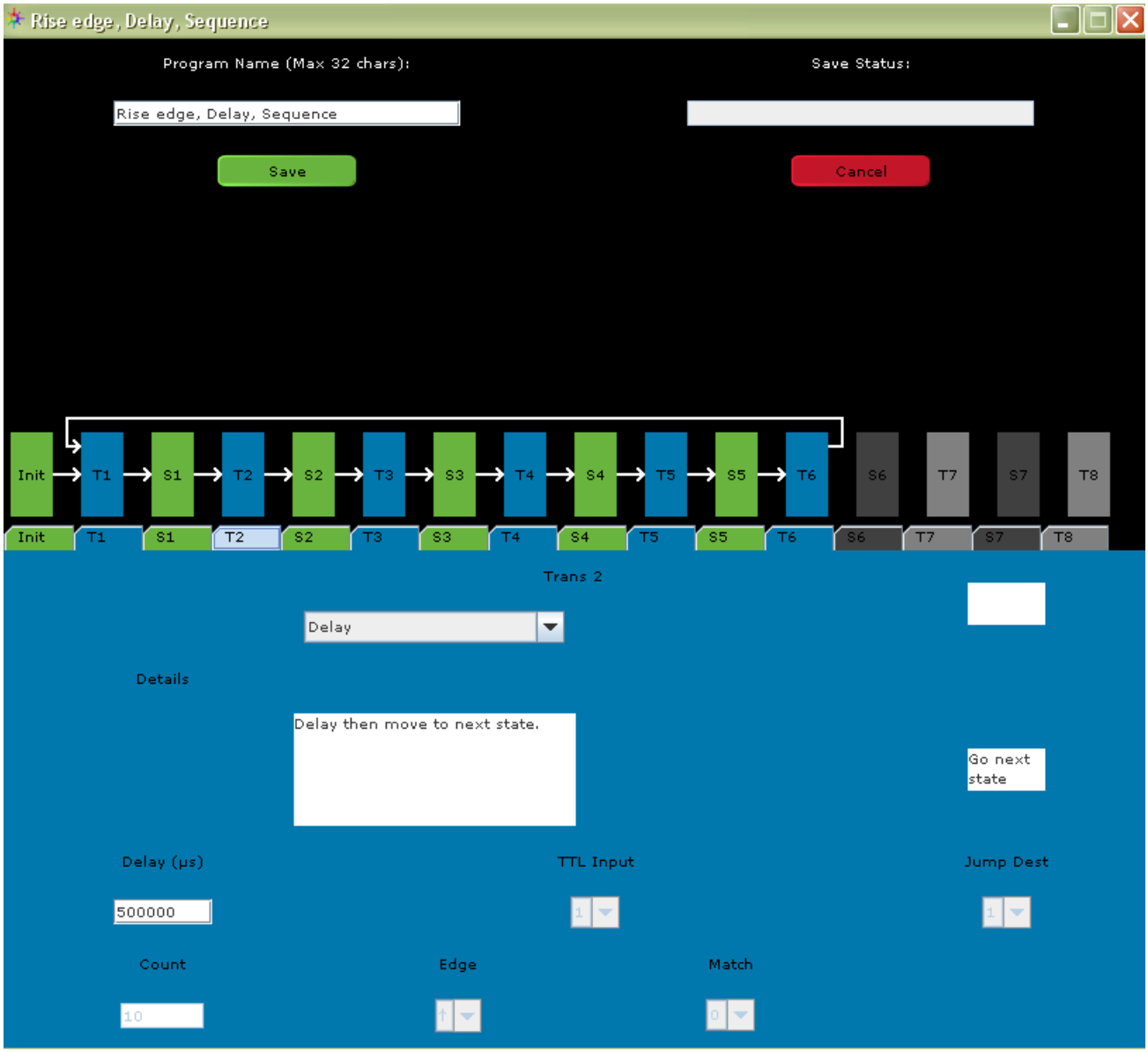
In the first state, S1, the first module is turned on and all other modules remain unchanged.

State 1:



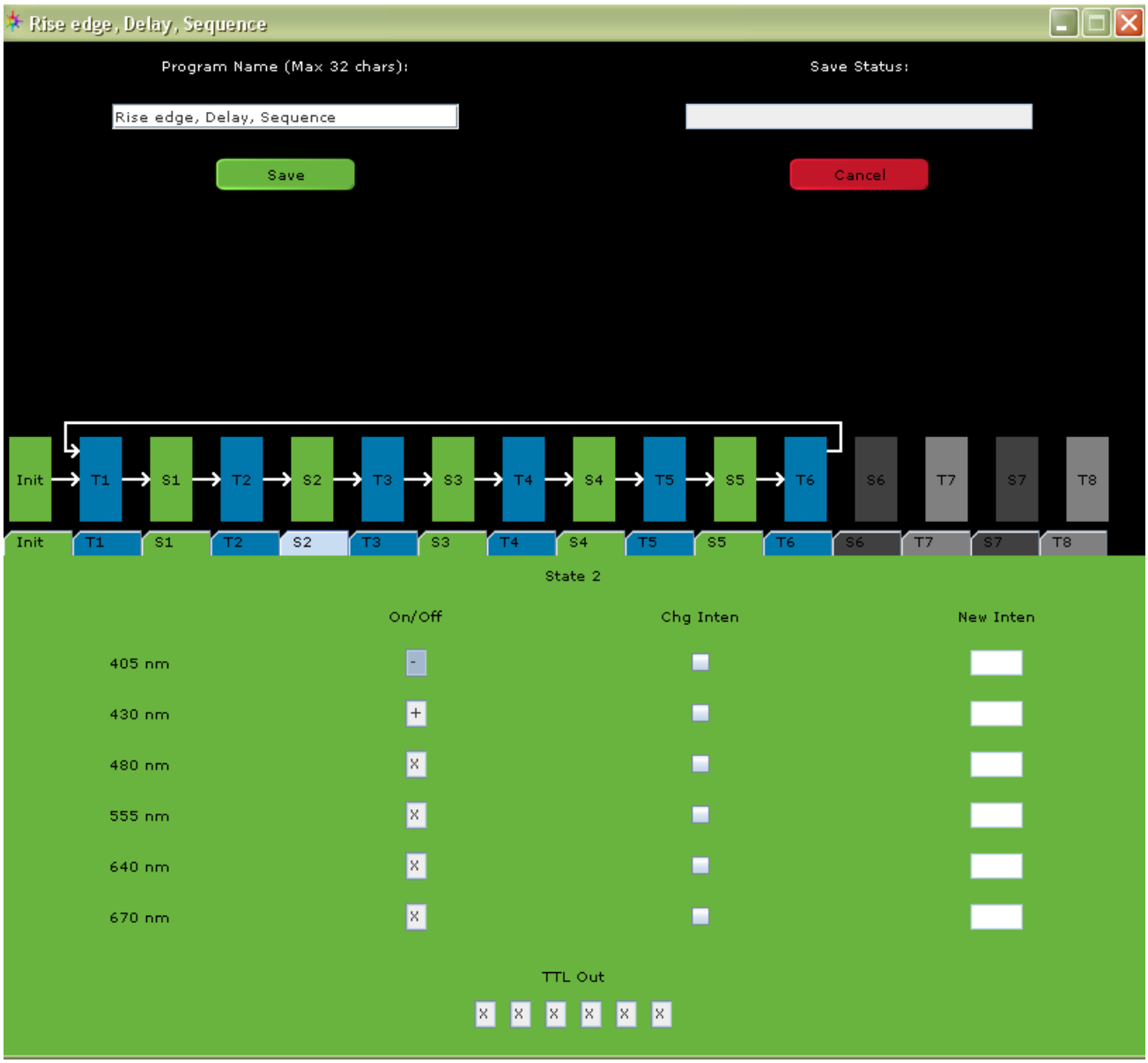
The next transition, T2, is a simple delay for 500.0 milliseconds.

Transition 2:



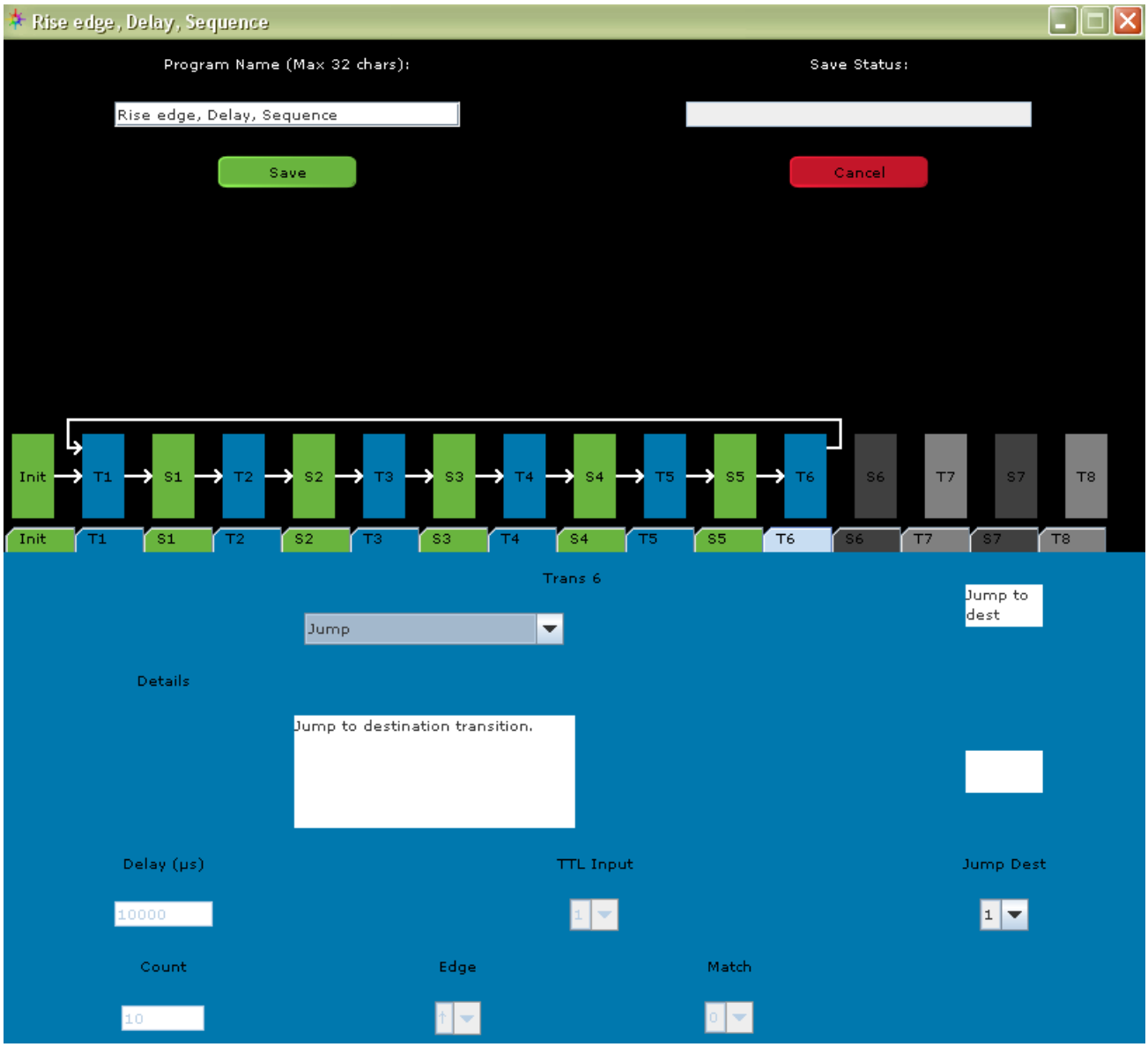
In the next state, S2, the first module is turned off, the second module is turned on, and all other modules are unchanged.

State 2:



The subsequent transitions and states alternate so that the first three modules are turned on and off in sequence with a delay between each. Also note that S4 and S5 send TTL output signals on TTL output channel 1. This could be used, for example, to move a stage as the program nears completion. The final transition, T6, is used to create a loop. Note the schematic indicates this with a white arrow pointing back to T1.

Transition 6:



b. Text File Implementation

```
pn2
ptRise edge, Delay, Sequence
cil1-l2-l3-ta000001
ct1i1rd10000
cs1l1+
ct2d500000
cs2l1-l2+
ct3d500000
cs3l2-l3+
ct4d500000
cs4l3-t11
ct5d10000
cs5t10
ct6j1
pe
```

3. PROGRAM 3: “250 MSEC SWITCH”

The objective of this program is to turn each of three modules on and off in sequence, for 250 milliseconds each. Additionally, this program demonstrates the use of the following transitions:

- Configured, no processing
- Delay
- Jump

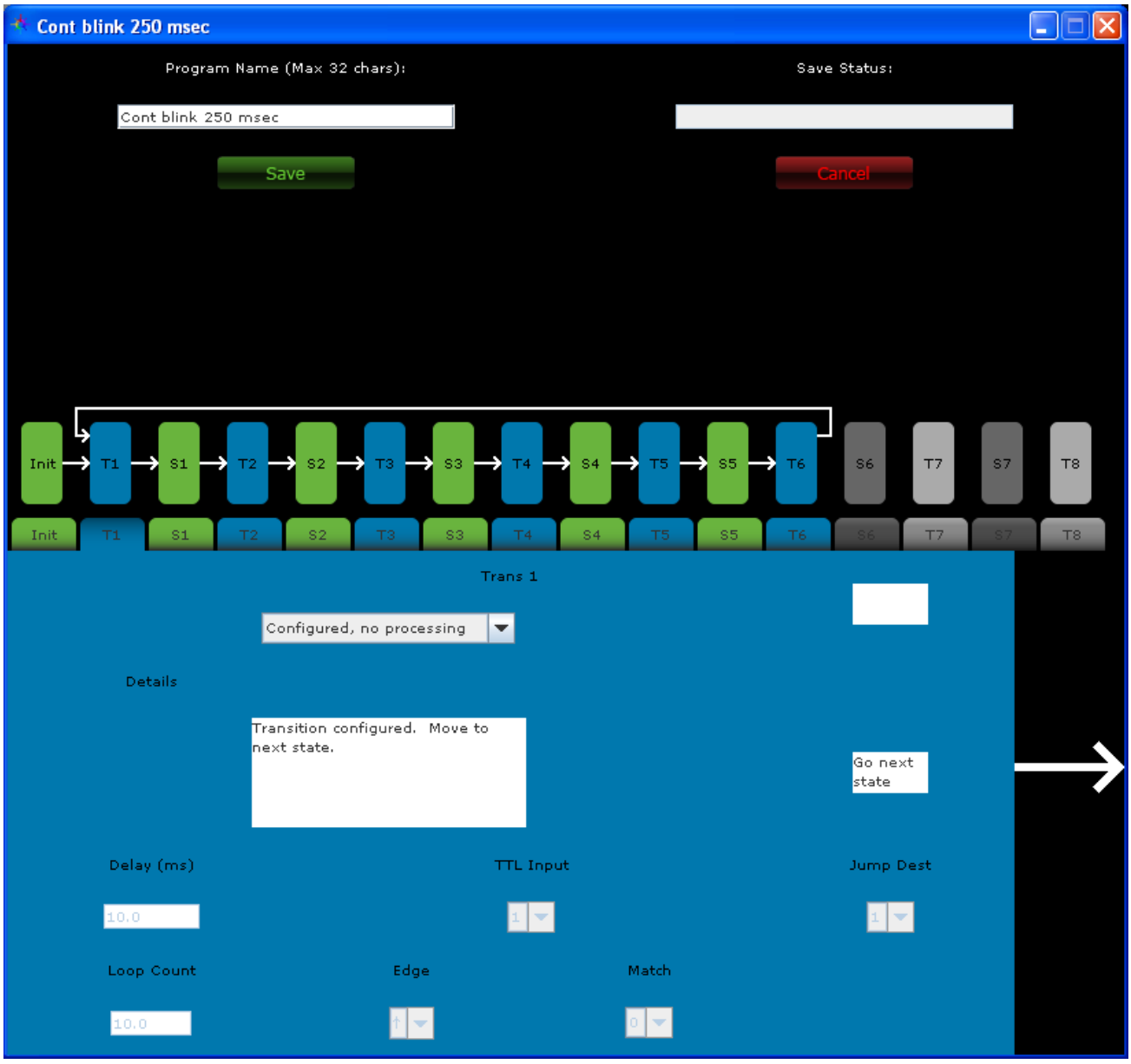
a. Program Tab Implementation

The initial state for this program is for the first module to be powered on; note the plus sign in the checkbox.

Initial State:

Proceeding to the first transition, T1, we see that no action is taken and so we progress directly to the first state, S1.

Transition 1:

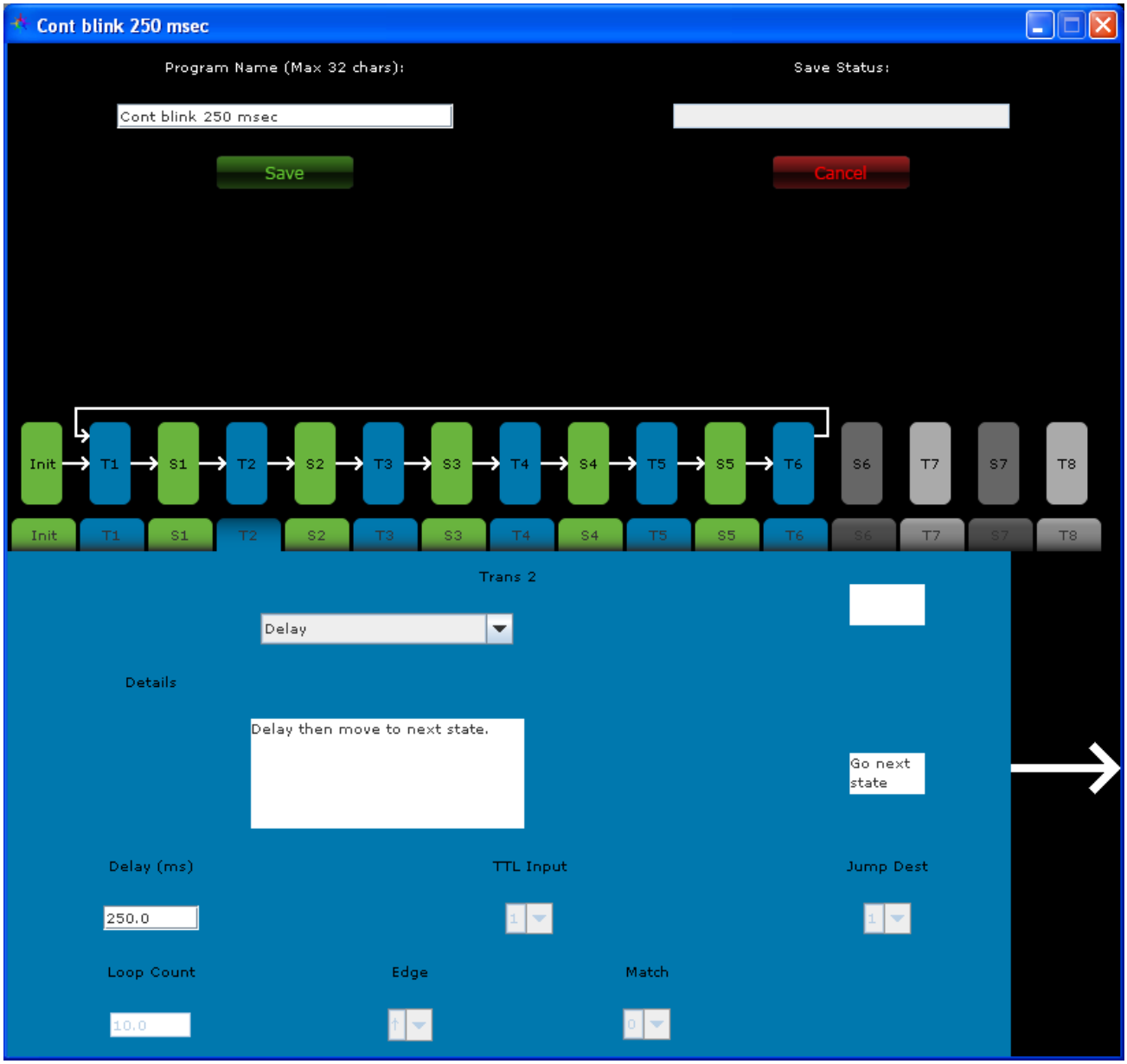


In S1, as in the initial state, the first module is ON and the others remain unchanged.

State 1:

In the second transition, T2, we have a delay of 250.0 milliseconds.

Transition2:



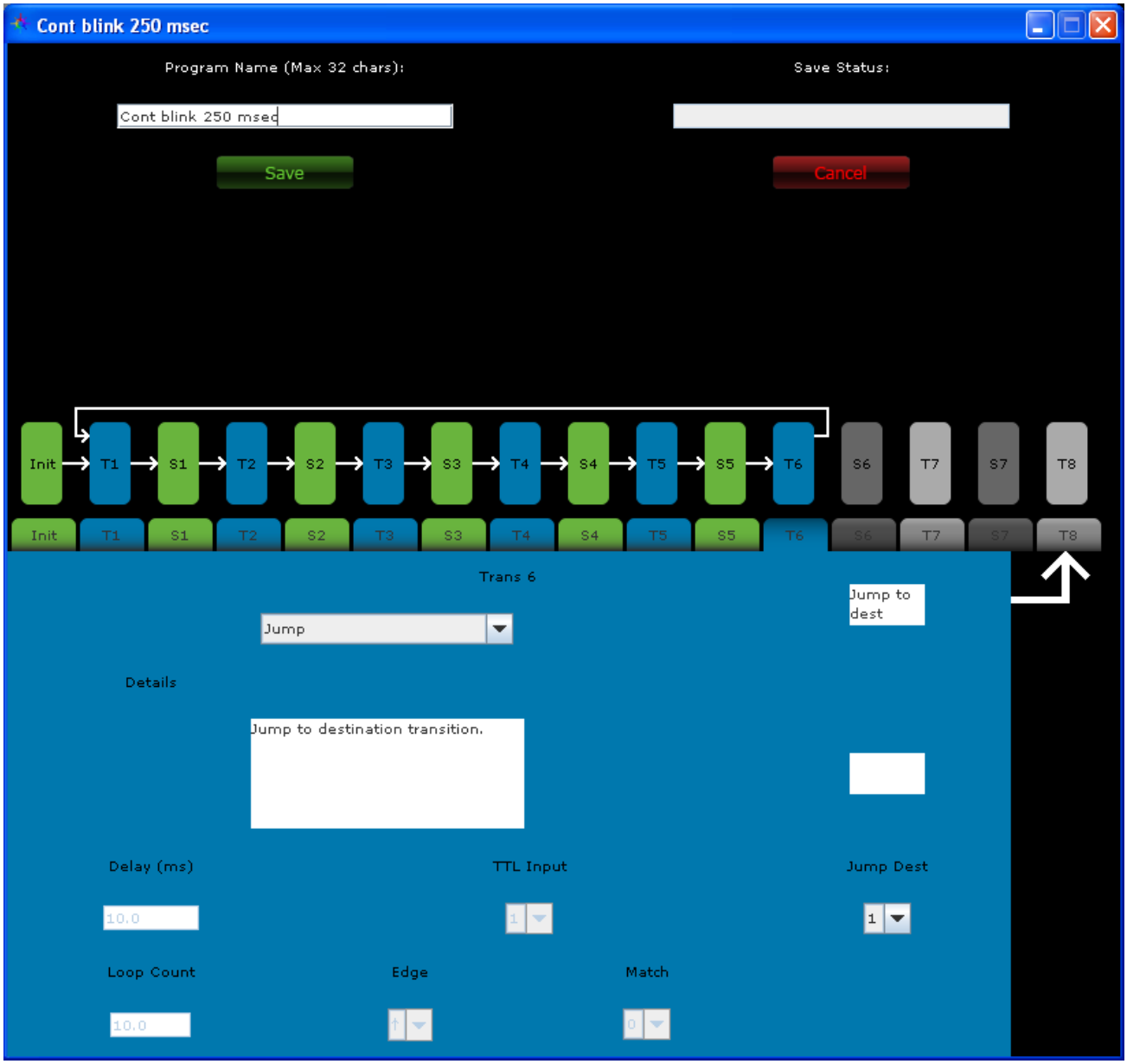
In S2, the first module is powered off (note the minus sign in its checkbox) and the second module is powered on (note the plus sign in its checkbox), while the others remain unchanged.

State 2:

In the next (not shown) states and transitions, there are 3 more delays (T3, T4, and T5) and three more states in which modules are switched on and off (S3, S4, S5).

The sixth and final transition, T6, however, is unique in that it is a jump back to T1.

Transition 6:



This effectively creates a loop and forms a program that causes the modules to flash in sequence until the program is stopped by the user. Note that this loop is indicated visually by the white arrow in the diagram in the middle of the screen. These arrows can assist the user when trying to understand or create a program by making the flow of the program readily apparent.

b. Text File Implementation

pn3
ptCont blink 250 msec
cil1-l2-l3-ta000001
ct1
cs1l1+
ct2d250000
cs2l1-l2+
ct3d250000
cs3l2-l3+
ct4d250000
cs4l3-t11
ct5d250000
cs5t10
ct6j1
pe

4. PROGRAM 4: “BLANK ON READOUT”

This final example demonstrates how a program could be used to keep modules on at all times, except when a camera is reading out. This is accomplished using the read signal from the camera. A rising edge on the TTL signal turns the modules off, and a TTL low signal turns them back on. This program demonstrates the use of the following transitions:

- TTL Decision
- TTL Edge
- Jump

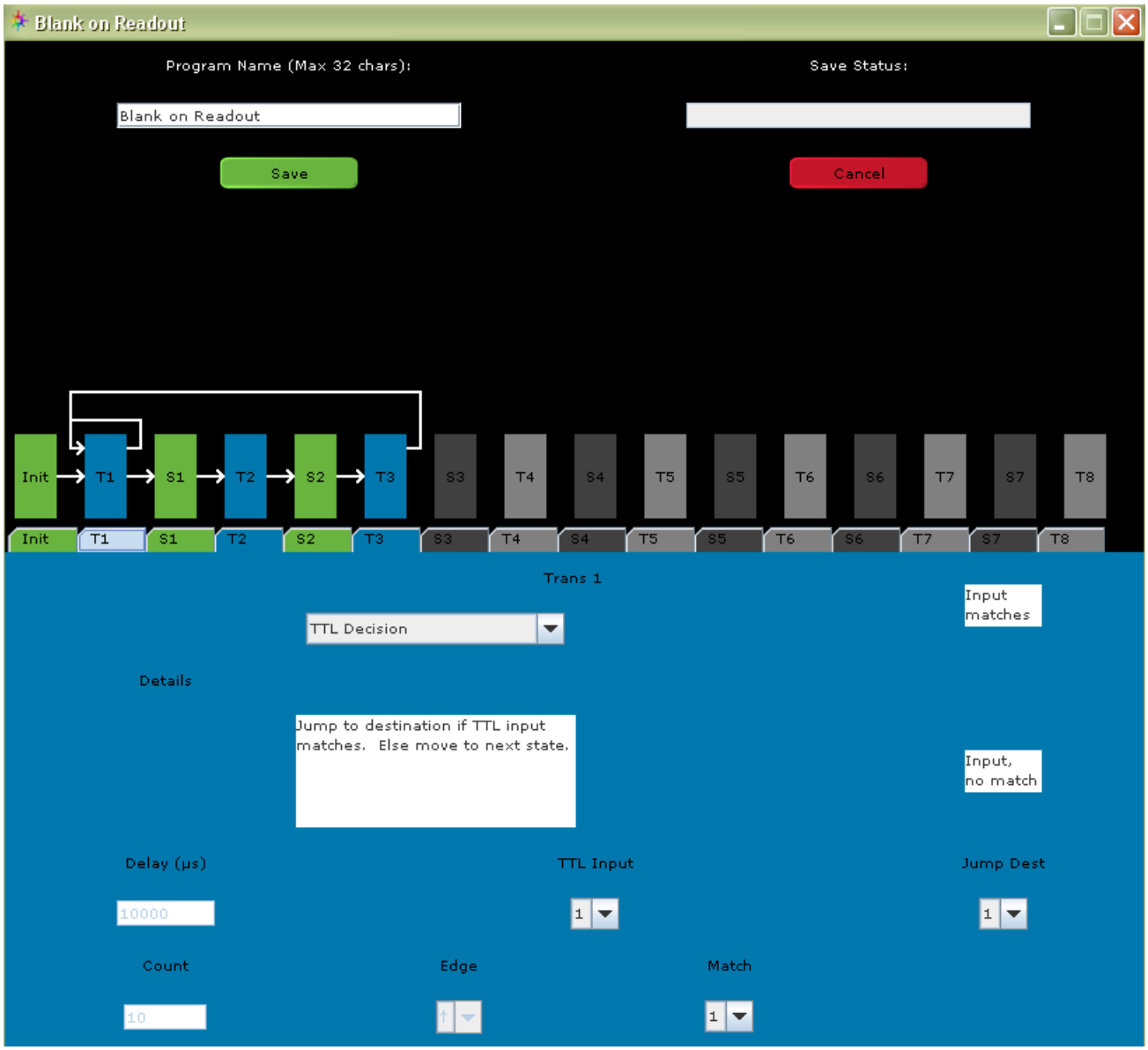
a. Program Tab Implementation

As with other programs, the initial state indicates that all modules are off. However, note that a value of 1 is output to TTL channel 1.

Initial State:

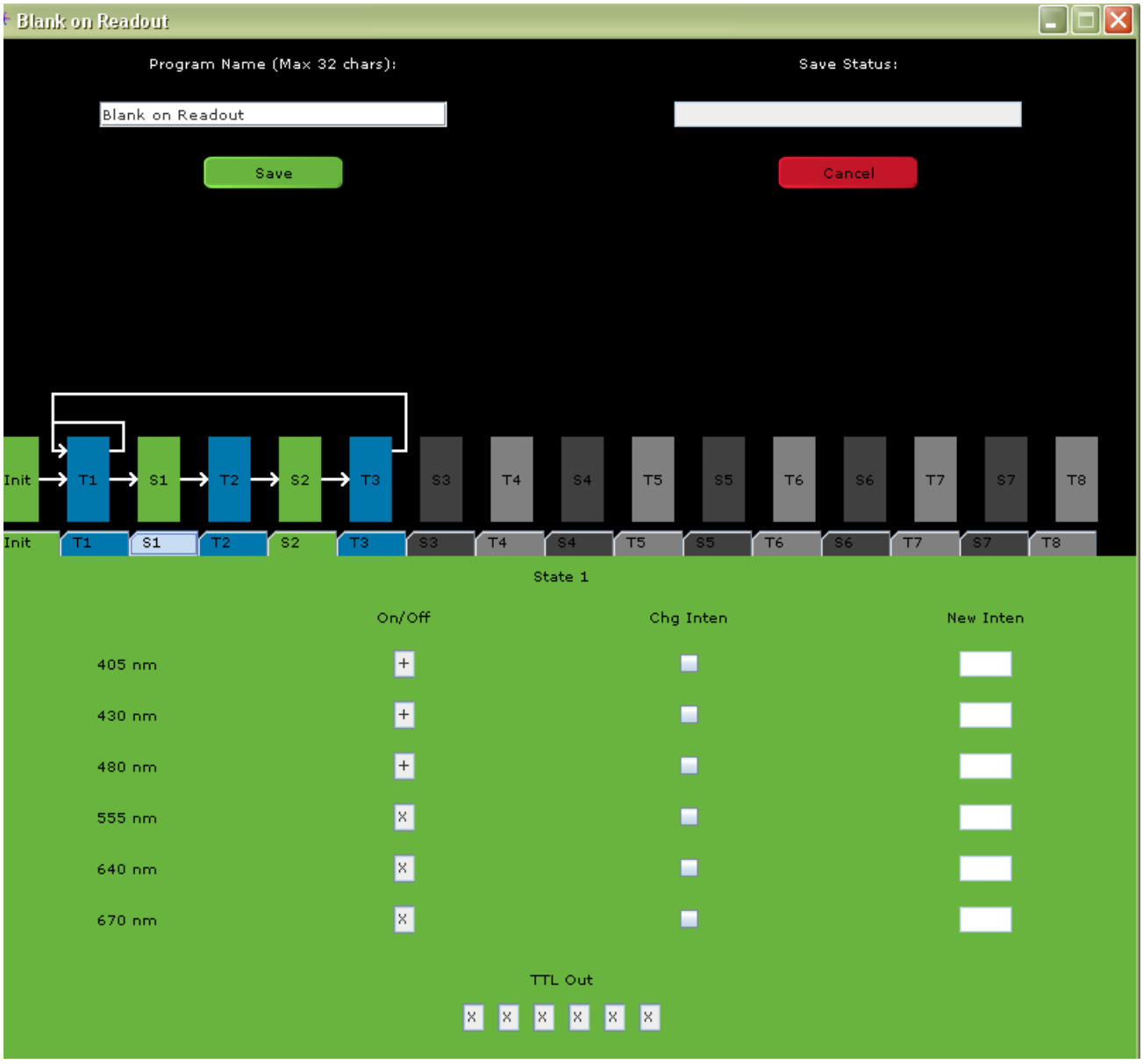
The first transition, T1, is a TTL decision: a match is sought on TTL input channel 1. The match value is 1 and, thus, a high voltage on input channel 1 will cause the program to jump to T1. This means the program will remain in T1 for as long as a high voltage is present on TTL input channel 1. A loop is created, as indicated by the white arrows in the diagram. A value not equal to 1 (a low voltage) on TTL input channel 1 will cause the program to advance to the first state, S1.

Transition 2:



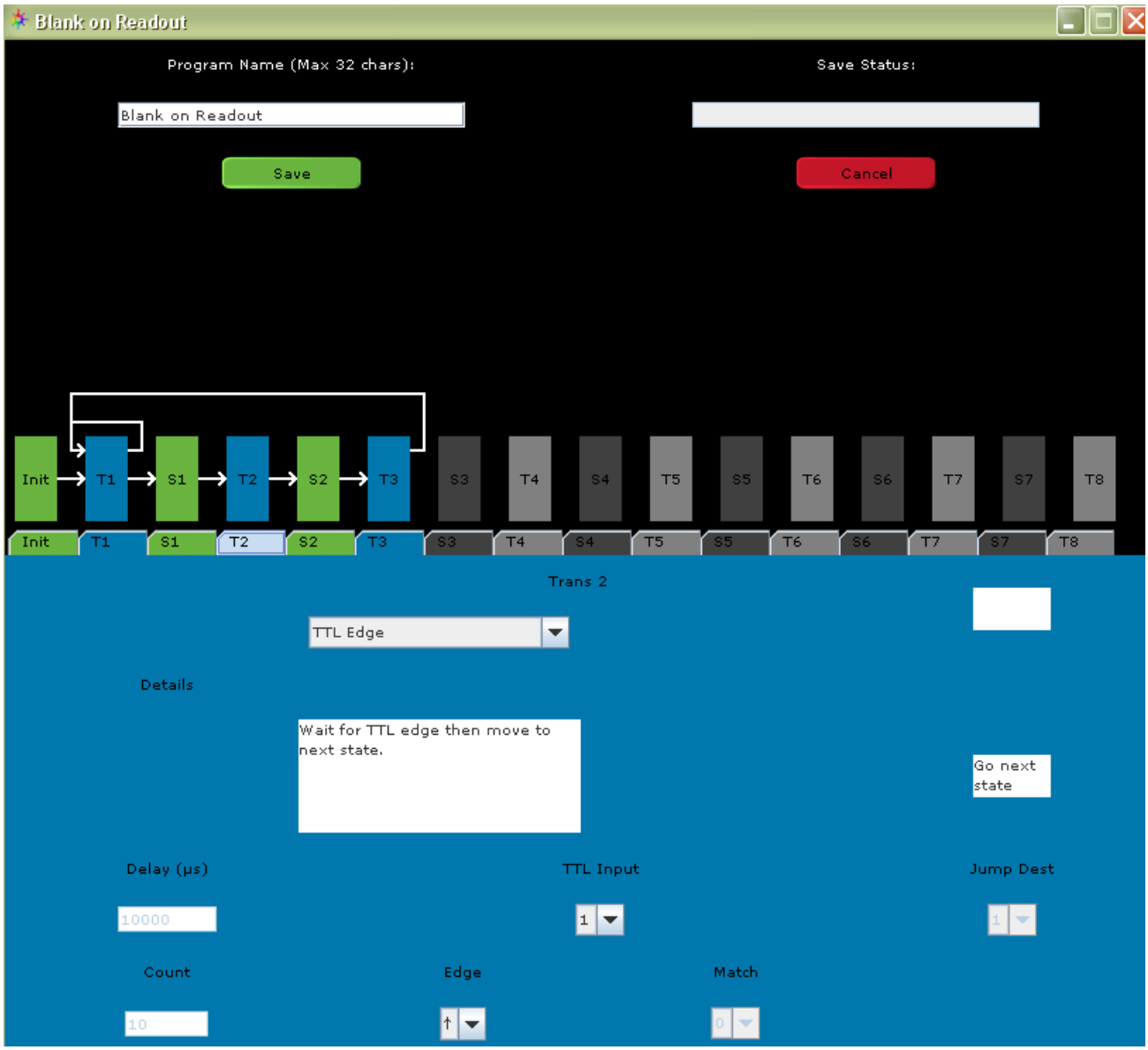
In S1, the first, second, and third modules are turned on.

State 1:



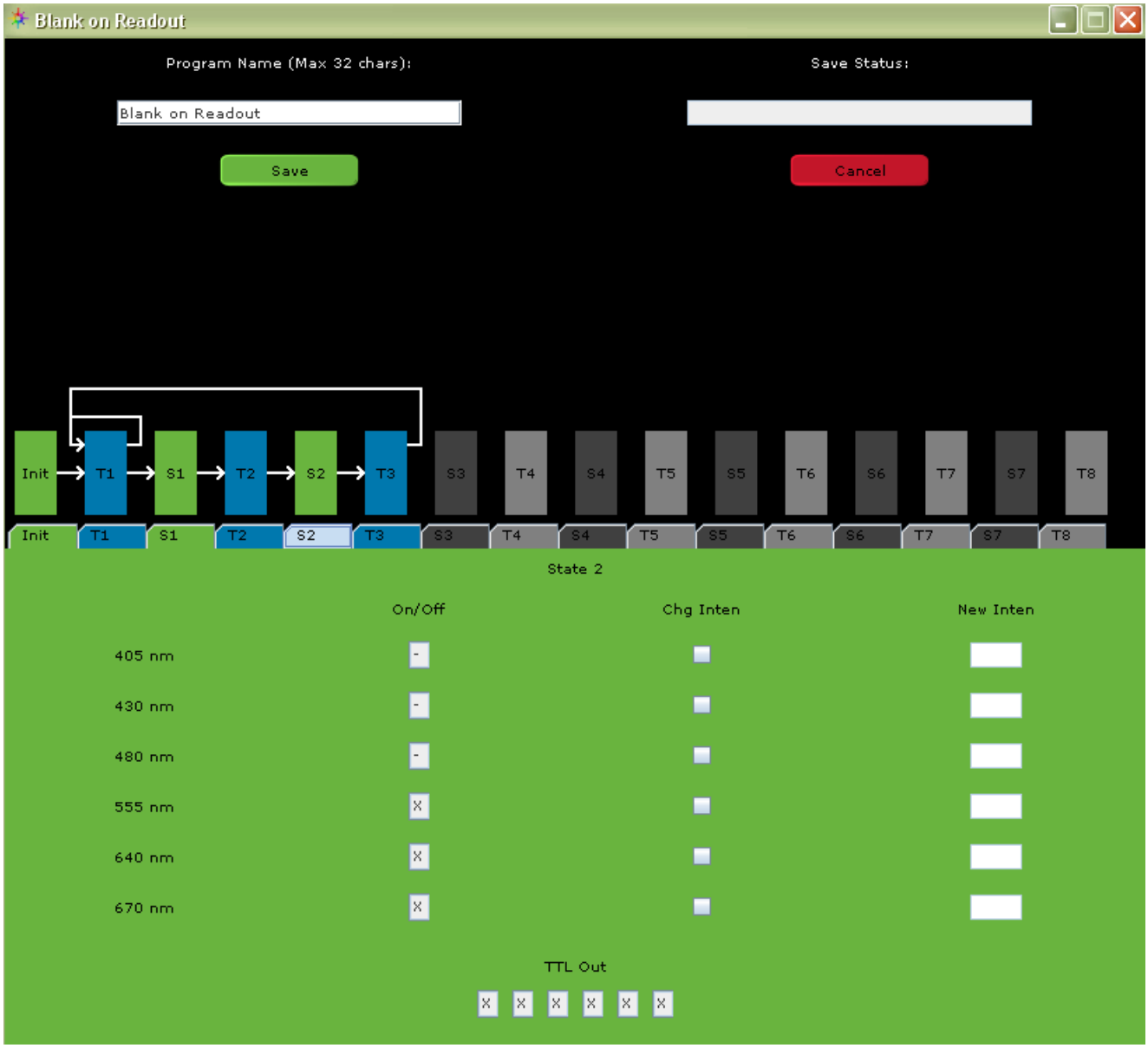
In T2, the program waits for a TTL edge. Note that a rising edge on TTL channel 1 is required before the program can proceed to the next state.

Transition 2:



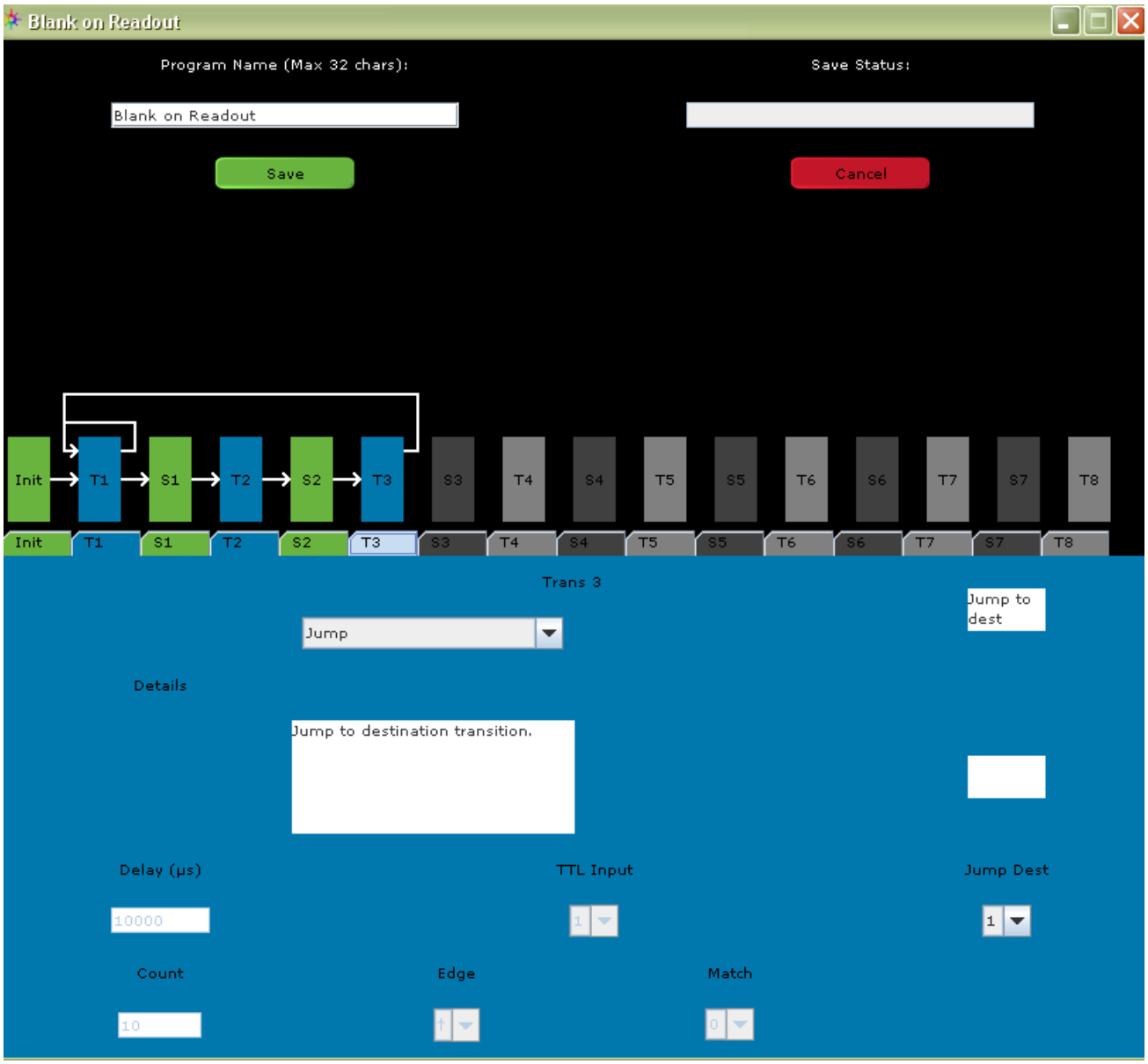
In S2, the first, second, and third modules are turned back off.

State 2:



The third and final transition, T3 is simply a jump back to T1. Note that this loops the entire program as indicated by the white arrow in the diagram.

Transition 3:



b. Text File Implementation

pn4

ptBlank on Readout

cil1-l2-l3-ta000001

ct1j1t11

cs1l1+l2+l3+

ct2i1r

cs2l1-l2-l3-

ct3j1

pe