

Optogenetics-Photometry Hardware & Software System

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GitHub: <https://github.com/HuimiaoChen/Optogenetics-Photometry-System>

v1: basic version.

v2: add the "help" page.

v3: add the toolbar with the "config save" and "config load".

v4: fix a "config load" bug.

v4.1: fix a "config load" bug and a default setting bug; revise the help page.

v5: update the whole system to support more advanced control; improve the latency of the control; frequency and period can be non-integers; add NiDaq output data saving (input data and video have to be saved); add separate stage control for different lasers; add video recording control; add rotary encoder recording control; add photometry recording control; a completely new version, but the control of UV is not enabled because of hardware.

v6: synchronization of visual stimuli and opto/photometry is added; probably some other small improvements.

Use MATLAB 2022b or newer versions.

Pre-Period: during the pre-period, the output signals are always 0 volts (TTL low).

Stimulation Period: during the stimulation period, each color light is set separately, please calculate the parameters of them carefully so that they achieve the desired outputs. We have a start time (delay time with 0 volt output after stimulation period starts) and at most 4 stages for each color. Each stage can have its own frequency and duty ratio for both the red and blue light. If you need less than 4 stages, turn off some of them. For example, you need only 2 stage, then you can turn off any 2 stages and the remaining 2 stages are labeled as Stage 1 and Stage 2. The stimulation period ends when it runs out the time. For example, if your red start time is bigger than stimulation period, then the output of red is always zero and the settings of res stages will not be used. If a color's four stage are all "Off", then it gives 0-volt output during the stimulation. We also have left time. Start time is zero input at the beginning of stimulation; and left time is zero input duration at the end of stimulation.

Freq should be a positive number. If you want constant TTL low (high), set Duty Ratio to 0 (1) with Freq being any positive number.

Duty Ratio should be between 0 and 100.

Duration should be a nonnegative number.

Red light uses the Analog Output 0;

Blue uses the Analog Output 1;

UV uses the Dig

Photometry:

analog input "aio" for photometry positive;

analog input "ai4" for photometry negative.

Rotary encoder:

analog input "ai1" for rotary encoder port 1 -- Enc1 (White of our audio cable);

analog input "ai5" for rotary encoder port 2 -- Enc2 (Red of our audio cable).

"ai2" for synchronization between the visual stimuli computer and the opto computer.

Post-Period: during the post-period, the output signals are always 0 volts (TTL low) so that laser sources are shut down and you have time to disconnect the cables or turn off the devices. Use nonnegative number.

Note: If the coder report error, the "Start" button is keeping disenabled and you need to restart the GUI.

Note: 'whole_signalData', 'scanData_timetable', 'video_data', 'scanData_matrix', 'video_start_time', 'exp_start_time', 'exp_end_time', 'video_end_time' are saved to "expData_yyyymmddHHMMSS.mat" file. Time is represented in double-precision floating-point number (datenum format in MATLAB), which is how many days passed since the time: January 1, 0000, at 00:00:00 (midnight). To convert 'exp_start_time' to datetime form, use `datetime(exp_start_time, 'ConvertFrom', 'datenum')`.

Note: the analog input frame number (and its rate) is slightly lower than the output frame number and rate especially there are multiple inputs. The output is stable.

Below are notes for devices.

Note 1: the laser device (635 nm, red) can only be controlled by TTL signals so we need to let TTL signals be high to adjust the intensity of the laser. TTL high is > 2.5 V. The analog input is in the range of 0-2.5V; for TTL: > 2.5V to full output. When the input voltage is lower than 2.5V, the red laser becomes in analog mode. The knob can change the magnitude of the intensity, making the intensity vary proportionally.

Note 2: the laser device (473 nm, blue) can be controlled by both TTL signals and analog signals (there is a switch for changing the mode), but we only use TTL control and let TTL signals be high to adjust the intensity of the laser. TTL high is > 2.3 V; TTL low is < 0.7 V. Analog control is between 0 and 5 V (off: < 0.7 V).

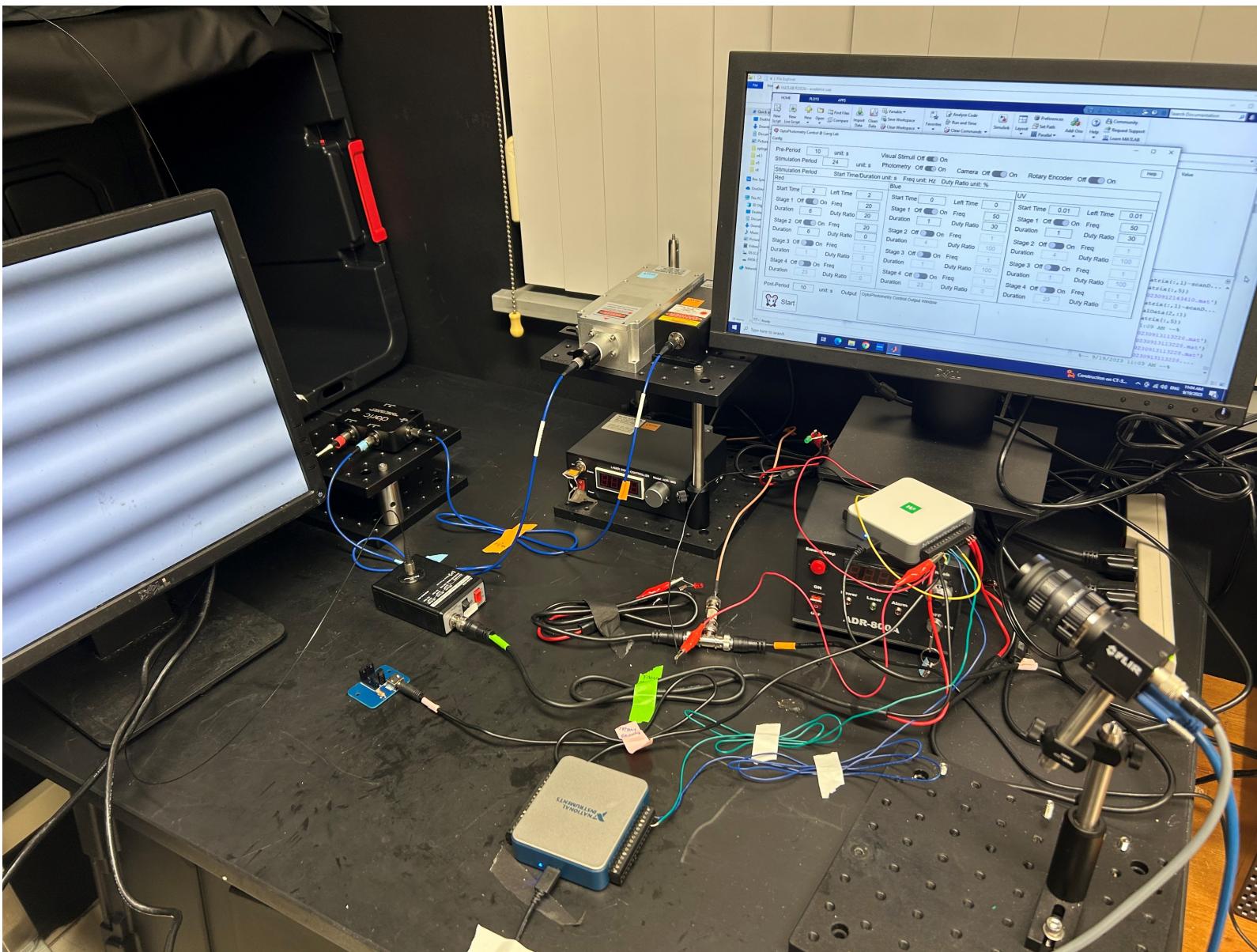
Note 3: we can only use the knob to adjust the light intensity of the laser devices when TTL control is not connected or it is connected and the signal is high; we cannot do that **when the TTL control cable is enabled/connected but TTL is low or no signal**.

Note 4: the LED (Plex) driver (used for UV LED control) (not used currently) can be used to replace a laser device. It can be controlled by both TTL signals and analog signals. TTL high is > 2 V; TTL low is < 0.7 V. Analog control is between 0 and 5 V.

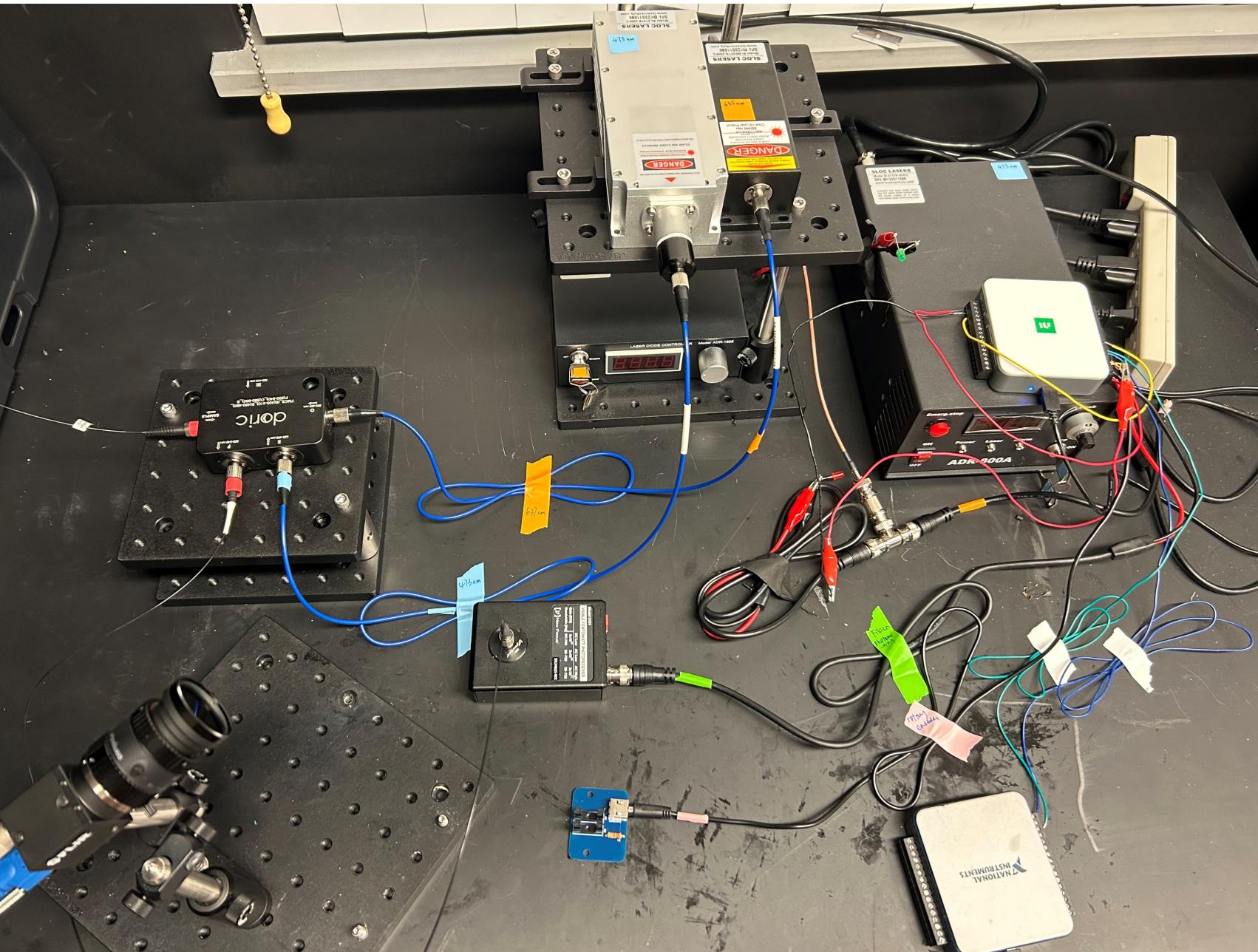
Note 5: rotary encoder - Sleeve (S) connected to Ground (Yellow of our audio cable); Ring 2 (R2) connected to 5V (Black/Green? of our audio cable); Ring 1 (R1) connected to Enc1 (White of our audio cable); Tip (T) connected to Enc2 (Red of our audio cable).

Note 6: photometry uses differential measure; connect the D GND (Digital Ground) to AI GND (Analog Input Ground) and connect +5 port to analog input "ai4". Because isolated measurement is not allowed according to NiDaq manual.

Hardware



Hardware



GUI of v1 – v4

Optogenetics Control @ Liang Lab

Config

Pre-Period unit: s Help

Stimulation Period

Cycle Number	<input type="text" value="20"/>	Duration unit: s	Freq unit: Hz	Duty Ratio unit: %
Stage 1	Off <input checked="" type="checkbox"/> On	Red Freq <input type="text" value="20"/>	Blue Freq <input type="text" value="1"/>	
Duration	<input type="text" value="2"/>	Red Duty Ratio <input type="text" value="20"/>	Blue Duty Ratio <input type="text" value="0"/>	
Stage 2	Off <input checked="" type="checkbox"/> On	Red Freq <input type="text" value="20"/>	Blue Freq <input type="text" value="1"/>	
Duration	<input type="text" value="4"/>	Red Duty Ratio <input type="text" value="20"/>	Blue Duty Ratio <input type="text" value="100"/>	
Stage 3	Off <input checked="" type="checkbox"/> On	Red Freq <input type="text" value="1"/>	Blue Freq <input type="text" value="1"/>	
Duration	<input type="text" value="1"/>	Red Duty Ratio <input type="text" value="0"/>	Blue Duty Ratio <input type="text" value="100"/>	
Stage 4	Off <input checked="" type="checkbox"/> On	Red Freq <input type="text" value="1"/>	Blue Freq <input type="text" value="1"/>	
Duration	<input type="text" value="23"/>	Red Duty Ratio <input type="text" value="0"/>	Blue Duty Ratio <input type="text" value="0"/>	

Post-Period unit: s Output Optogenetics Control Output Window

 Start

GUI of v5 or later

Optogenetics Control @ Liang Lab

Config

Pre-Period unit: s Help

Stimulation Period unit: s Photometry Off On Camera Off On Rotary Encoder Off On

Stimulation Period	Start Time/Duration unit: s	Freq unit: Hz	Duty Ratio unit: %
Red			
Start Time <input type="text" value="2"/>	Start Time <input type="text" value="0"/>	Start Time <input type="text" value="0.01"/>	UV
Stage 1 Off <input type="radio"/> On <input type="radio"/> Freq <input type="text" value="20"/>	Stage 1 Off <input type="radio"/> On <input type="radio"/> Freq <input type="text" value="50"/>	Stage 1 Off <input type="radio"/> On <input type="radio"/> Freq <input type="text" value="50"/>	
Duration <input type="text" value="6"/> Duty Ratio <input type="text" value="20"/>	Duration <input type="text" value="1"/> Duty Ratio <input type="text" value="30"/>	Duration <input type="text" value="1"/> Duty Ratio <input type="text" value="30"/>	
Stage 2 Off <input type="radio"/> On <input type="radio"/> Freq <input type="text" value="20"/>	Stage 2 Off <input type="radio"/> On <input type="radio"/> Freq <input type="text" value="1"/>	Stage 2 Off <input type="radio"/> On <input type="radio"/> Freq <input type="text" value="1"/>	
Duration <input type="text" value="6"/> Duty Ratio <input type="text" value="0"/>	Duration <input type="text" value="4"/> Duty Ratio <input type="text" value="100"/>	Duration <input type="text" value="4"/> Duty Ratio <input type="text" value="100"/>	
Stage 3 Off <input type="radio"/> On <input type="radio"/> Freq <input type="text" value="1"/>	Stage 3 Off <input type="radio"/> On <input type="radio"/> Freq <input type="text" value="1"/>	Stage 3 Off <input type="radio"/> On <input type="radio"/> Freq <input type="text" value="1"/>	
Duration <input type="text" value="1"/> Duty Ratio <input type="text" value="0"/>	Duration <input type="text" value="1"/> Duty Ratio <input type="text" value="100"/>	Duration <input type="text" value="1"/> Duty Ratio <input type="text" value="100"/>	
Stage 4 Off <input type="radio"/> On <input type="radio"/> Freq <input type="text" value="1"/>	Stage 4 Off <input type="radio"/> On <input type="radio"/> Freq <input type="text" value="1"/>	Stage 4 Off <input type="radio"/> On <input type="radio"/> Freq <input type="text" value="1"/>	
Duration <input type="text" value="23"/> Duty Ratio <input type="text" value="0"/>	Duration <input type="text" value="23"/> Duty Ratio <input type="text" value="0"/>	Duration <input type="text" value="23"/> Duty Ratio <input type="text" value="0"/>	

Post-Period unit: s Output OptoPhotometry Control Output Window

 Start

GUI of v5 or later

OptoPhotometry Control @ Liang Lab

Config

Pre-Period unit: s

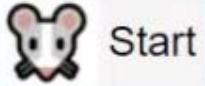
Stimulation Period unit: s

Photometry Off On

Camera Off On

Rotary Encoder Off On

Help

Stimulation Period	Start Time/Duration unit: s	Freq unit: Hz	Duty Ratio unit: %
Red			
Start Time	<input type="text" value="2"/>		
Stage 1	Off <input checked="" type="radio"/> On <input type="radio"/>	Freq <input type="text" value="20"/>	
Duration	<input type="text" value="2"/>	Duty Ratio <input type="text" value="20"/>	
Stage 2	Off <input checked="" type="radio"/> On <input type="radio"/>	Freq <input type="text" value="20"/>	
Duration	<input type="text" value="2"/>	Duty Ratio <input type="text" value="0"/>	
Stage 3	Off <input checked="" type="radio"/> On <input type="radio"/>	Freq <input type="text" value="1"/>	
Duration	<input type="text" value="1"/>	Duty Ratio <input type="text" value="0"/>	
Stage 4	Off <input checked="" type="radio"/> On <input type="radio"/>	Freq <input type="text" value="1"/>	
Duration	<input type="text" value="23"/>	Duty Ratio <input type="text" value="0"/>	
Blue			
Start Time	<input type="text" value="0"/>		
Stage 1	Off <input checked="" type="radio"/> On <input type="radio"/>	Freq <input type="text" value="50"/>	
Duration	<input type="text" value="1"/>	Duty Ratio <input type="text" value="30"/>	
Stage 2	Off <input checked="" type="radio"/> On <input type="radio"/>	Freq <input type="text" value="1"/>	
Duration	<input type="text" value="4"/>	Duty Ratio <input type="text" value="100"/>	
Stage 3	Off <input checked="" type="radio"/> On <input type="radio"/>	Freq <input type="text" value="1"/>	
Duration	<input type="text" value="1"/>	Duty Ratio <input type="text" value="100"/>	
Stage 4	Off <input checked="" type="radio"/> On <input type="radio"/>	Freq <input type="text" value="1"/>	
Duration	<input type="text" value="23"/>	Duty Ratio <input type="text" value="0"/>	
UV			
Start Time	<input type="text" value="0.01"/>		
Stage 1	Off <input checked="" type="radio"/> On <input type="radio"/>	Freq <input type="text" value="50"/>	
Duration	<input type="text" value="1"/>	Duty Ratio <input type="text" value="30"/>	
Stage 2	Off <input checked="" type="radio"/> On <input type="radio"/>	Freq <input type="text" value="1"/>	
Duration	<input type="text" value="4"/>	Duty Ratio <input type="text" value="100"/>	
Stage 3	Off <input checked="" type="radio"/> On <input type="radio"/>	Freq <input type="text" value="1"/>	
Duration	<input type="text" value="1"/>	Duty Ratio <input type="text" value="100"/>	
Stage 4	Off <input checked="" type="radio"/> On <input type="radio"/>	Freq <input type="text" value="1"/>	
Duration	<input type="text" value="23"/>	Duty Ratio <input type="text" value="0"/>	
Post-Period <input type="text" value="1"/> unit: s			
Output			
 Start	<p>NOW IS Stimulation Period. Blue signal output begins. Red signal output begins. Now is post-period. Experiment ends. Experiment total time: 0.20182 min (12.109 s). Data reading and saving begin. All done!</p>		
exp(3)+log(10)			