LC4 *Light Controller*

The LC4 Light Controller allows the DAMSystem3 software to directly schedule the on/off timing of up to 4 independent external devices.

By bypassing the simple internal timers that many incubators have, the Light Controller hardware and DAMSystem software combination makes available a wide array of light pulse patterns for both entrainment and stimulus/response purposes.

External devices such as the Troemner multi-tube vortexer may also be controlled to generate shake-pulse sequences for sleep deprivation.

LC4

Each of the 4 output channels is switched on/off by a solid state relay within the LC4 enclosure. The relays are rated for up to 240VAC, 50/60 hz operation at 3 amperes, and each is fuse protected against overload.

An input AC line cord provides power to the relays, and output cords provide switched power from the relays to the lights or devices to be switched. The connectors for AC input and output are the North American standards: IEC60320 C13 for input and NEMA 5-15 for output.

The unit is housed in a robust aluminum enclosure.

Features

- Programmable on/off switching of 4 AC outlets

- Pulse duration from 0.1 second to 99 hours

- Single, periodic, or random pulse repetition

- Incubator lighting control

- Troemner multi-tube vortexer pulsing for sleep deprivation

Specifications

- Power per outlet: 3A, 240VAC 50/60 hz

- AC power outlet (4): NEMA 5-15 (USA)

- AC Power Input: IEC60320 C13

- Dimensions: 6.8" x 4.8" x 4.2" LWH

- Enclosure material: Aluminum

- Interconnect: 4 wire, 6 position, RJ-11 modular telephone line jack to DAMSystem network for 9V DC power and data transmission

- Operating environment: normal laboratory, non-condensing

TRIKINETICS

Checkout

1. Launch the DAMSystem3 program and select Light Control in the Display Selector.

2. Click the upper-left box in the checkbox matrix to connect pulse 1 to output channel 1.

3. Connect the LC4 Light Controller to the DAMSystem network with a phone cable and select Current Data in the display selector. Verify that the light status box in the upper right of the DAMSystem window turns orange (on) or blue (off).

4. Connect an AC cord to the input power receptacle and a standard table lamp plug to one of the output receptacles. Adjust the settings in the Light Control panel to make the channel go on (at the next reading) and verify that the lamp does indeed come on.

5. Plug the incubator light or device cords into the output receptacles in place of the test lamp and adjust the settings to control the lights or devices as desired.
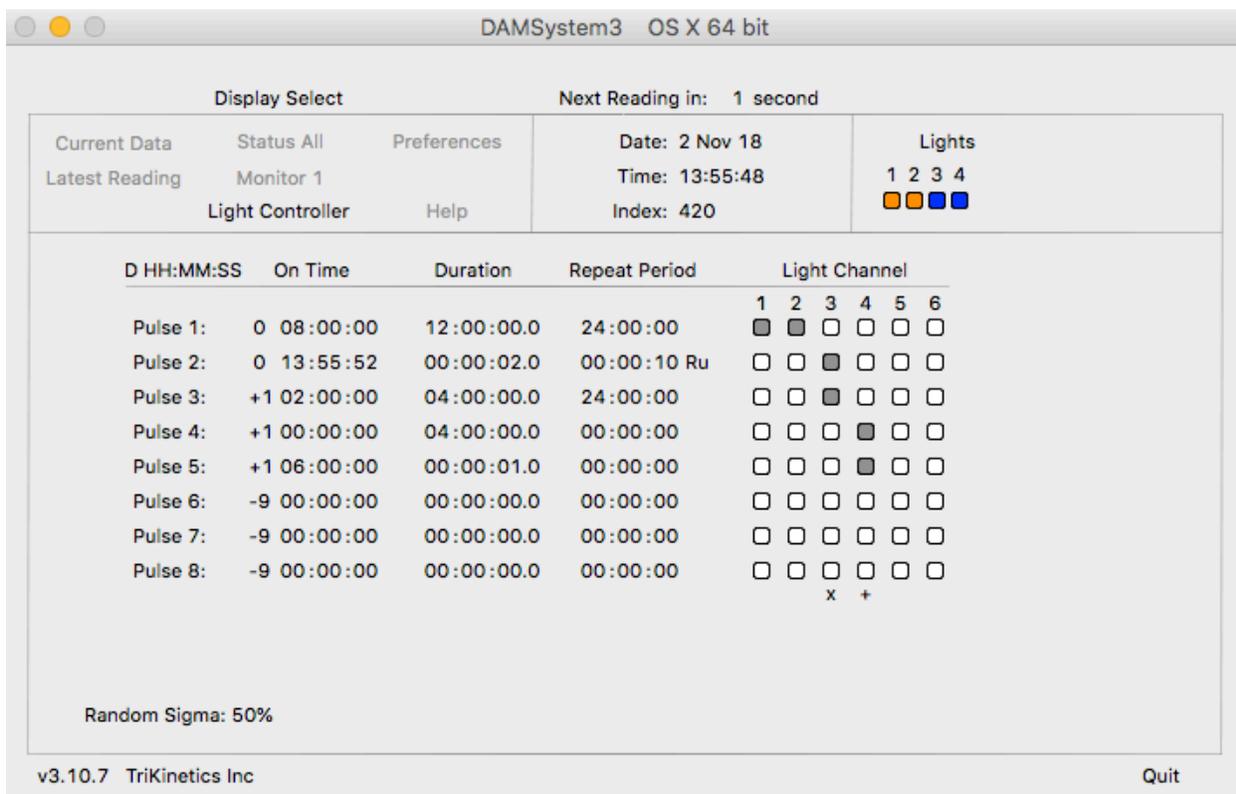
Light Controller Settings

Examples

Channels 1 and 2	24-hour light/dark cycle: On at 8:00 AM, Off at 8:00 PM
Channel 3	Randomized 2-second pulse every 10 seconds ONLY during the period between 02:00:00 and 06:00:00 every day. Note the use of 2 pulses combined with AND logic (output is on when both pulses are on.)
Channel 4	4-hour pulse at midnight followed by 1-second pulse at 6am. 2 pulses are combined by OR logic to control output channel 4 (the output will be on when either pulse is on.) No repeats will occur.

Light Channel Matrix

The software generates 8 independent pulses, each of which may be assigned to one or more of the 4 physical output channels according to the matrix of check boxes. An output channel with a single assigned pulse will be On when the pulse is On, and Off when the pulse is Off.

When multiple pulses are assigned to a single channel, the logic to combine them will be determined by the +/x symbol displayed below the pulse column. '+' (*or* logic) will cause the light channel to be on when *any* of its assigned pulses is on, and 'x' (*and* logic) will turn on the output only when *all* of the assigned pulses are on.

When an output channel is configured to be On, its corresponding outlet on the LC4 Light Controller will be energized with AC power.

Pulse Algorithm

Each pulse is individually controlled by 3 parameters: On Time, Duration, and Repeat Period. A pulse will be turned On when the Day of its On Time parameter is today (0), and the H:M:S of its On Time equals the H:M:S of the computer clock.

The pulse will then stay On for the H:M:S of its Duration parameter, after which it will go Off. As it does so, the Repeat Period parameter will be added to the On Time to form the new On Time for the next pulse. This On/Off cycle will continue at the Repeat Period for as long as the program is operating.

Several special cases are of interest. If the Duration is 0, the pulse will never turn On. If the Duration equals the Repeat Period, the pulse will never turn Off. If the Repeat Period is 0, only a single pulse will be output, and it will not be repeated.

Changing the Settings

To change a time setting, place the mouse pointer over the number to be modified, and hold down the (left) button. If the tip of the pointer is above the centerline, the number will increment, and if below, it will decrement. Note that some settings are restricted to multiples of the Reading Interval.

On Time

The On Time for each light pulse indicates the time of day at which the pulse either was, or will be, turned On. The digit in front of the hour indicates the day of turn-on, with '0' for today, '-1' for yesterday, and '+1' for tomorrow. As light pulses are turned on only at the Reading Interval, the On Time is restricted to multiples of this interval.

Duration

The Duration sets the length of time for which the pulse is to remain On after turn-on. The value may range from 00:00:00.0 (never On) to that of the Repeat Period (always On). If the Duration is set above the Repeat Period, it will be set to the Repeat Period when the settings are saved. The timing resolution is 0.1 second.

Repeat Period

The Repeat Period sets the rate of pulse cycling, and with the Duration, controls the duty cycle or 'On fraction' of the pulse. The pulse will be On for (Duration/Repeat Period) fraction of the time. If the Repeat Period is set to 0, only a single pulse will be output, and it will not be repeated. The maximum setting is 99 hours, or just over 4 days at 24 hours each.

Random Repeat Period

The Repeat Period may be randomized to vary the stimulation from pulse to pulse. To activate this function for any pulse, click in the space to the right of the Repeat Period, toggling through 3 options: Rn(randomize normal), Ru(randomize uniform), and blank(no randomness). Operation is as follows:

For any pulse with its flag set to Rn, the Repeat Period becomes a normally-distributed random variable, with a mean equal to the nominal (displayed) value, and a standard deviation equal to the Sigma fraction of the nominal Off Time (Repeat Period - Duration). All Repeat Period values will be within the range of Repeat Period +/- Off Time. The Sigma parameter will adjust the width of the distribution, with 1% providing little variation in the Repeat Period, and 100% providing wide variation over the allowed range.

For any pulse with its flag set to Ru, the Repeat Period becomes a uniformly-distributed random variable, with a mean equal to the nominal (displayed) value, and a maximum deviation equal to Sigma times the nominal Off Time. Thus, in this case Sigma does not represent a true standard deviation, but instead defines the absolute limits of the uniform variation about the nominal value as a fraction of the nominal Off Time.

In all cases, an immediate repeat may be generated, but only at the conclusion of a pulse, and thus no partial pulse repeats will occur. Note that as long as the pulse duration is at least as great as the reading interval, the MonitorLC or DayLight file will contain a record of the pulse times. Note also that the pulses may only be initiated at the beginning of a bin, so the Repeat Period must be substantially greater than the Reading Interval for the randomizer to be effective.

Hints

A single pulse (of the 8) may be used to control multiple light channels if all are to cycle On/Off simultaneously. Simply check the boxes for these channels in the row of the pulse, and all will be controlled.

A finite string of pulses may be generated by combining several of the 8 pulses, each of which is set to produce a single pulse. Thus Pulse 1 could generate a single pulse today (0 H:M:S), Pulse 2 could generate a single pulse tomorrow (+1 H:M:S), and so on, up to 8 pulses.

A single long pulse may enable or gate a series of short pulses by using the 'x' (*and*) logic symbol. Thus a 1-hour sequence of short 1-minute pulses would be generated by "x" combining on a single channel the 1-hour pulse with a repeating 1-minute pulse. The channel output will only be On when both pulses are On. (If, however, the '+' (*or*) symbol is used instead, the channel will be On whenever *either* pulse is On, negating any effect of the 1-minute pulse.)

Notes

Light pulses are initiated only at bin boundaries, though they may terminate at any time according to the Duration setting. The light status boxes are updated as each bin begins, just prior to any command changes to the lights. Thus the status box and status record in the LC file reflect the state of the lights in the bin just ended (aligning itself with the data collected, which similarly reflects activity in the bin just ended.)

The light status boxes reflect the On/Off state of the lights as commanded by the software and reported back by the controller. If a fuse is blown or a cable unplugged, the status will clearly be incorrect, and only a direct measurement of the light level itself will tell the real story. (See DEnM Drosophila Environment Monitor or DAM2 Ambient Light Sensor.

Vortexer Control

The LC4 is often used to power a vortexer shaking apparatus for sleep deprivation. This requires short (2 second) pulses repeated often (every 10 seconds), the settings for which are shown above in example channel 3. Because pulses can only be initiated at the Reading Interval, it is usually best to operate the LC4 in this application on a separate PSIU9 and DAMSystem3 application with no activity monitors attached so that very short (2-second) Reading Intervals can be used. This is necessary for randomization of pulses at a 10-second Repeat Period.

Incubator Light Wiring

To use these controls for incubator lighting, the lights must be disconnected from the internal incubator timers and connected instead to conventional line cords with plugs suitable for connecting to wall power. Make sure that the ballast transformers for the lights are included in the circuit with the line cords - test each cord by plugging it into a wall outlet. If the lights work properly in this case, the cord may be plugged into the LC4 for DAMSystem control.

NOTE: electrical connections to the incubator lights *must* be made by trained electricians only.

Fuses

Fuses are provided in each of the relays to protect against overload. In the event of fuse replacement, the exact same size and rating *must* be used (Littlefuse 217005.)

Ghost Flashes

The LC4 solid-state relays can output a microamp-level current, even when off, which normally is of no consequence. But some compact fluorescent and led lamps can integrate this minuscule 'off' current over a period of seconds or minutes into enough voltage to periodically power the lamp on for a brief flash of light. (This will not occur with normal fluorescent or incandescent bulbs.)

To prevent this, place a small incandescent bulb, like a 3-watt refrigerator lamp, on the outside of the incubator and in parallel with the interior light which flashes. The load of the incandescent bulb when off will drain the microamp leakage current and prevent the flashing.