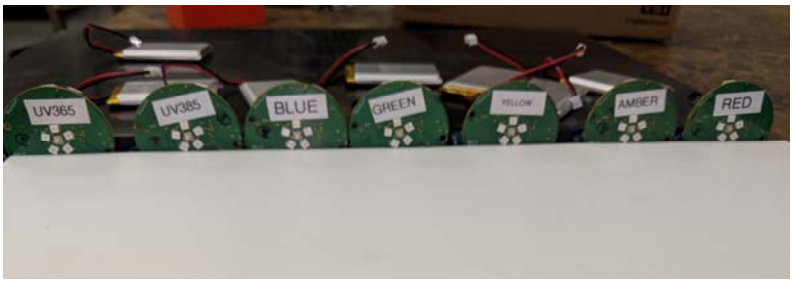
Smart-Trap Programmable Lighting v2

Experimental Platform for Enhanced Insect Trapping



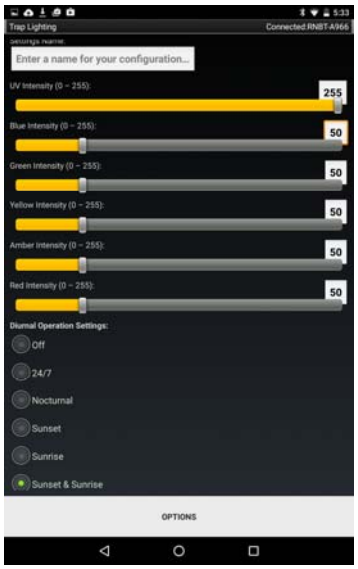


Table of Contents

Intended Use

The Smart-Trap programmable lighting device is intended for conducting experimental trials on insect lighting preference to enhance the effectiveness of traps. For testing multiple LED colors simultaneously, the user may consider using a "diffuser" (such as half of a ping-pong ball covering the LED array) to mix the different wavelengths together instead of projecting a "mosaic" pattern of different colors.

User Responsibility

Users are responsible for familiarizing themselves with the product instructions and information. The users should especially familiarize themselves with the safety information, and are responsible to provide appropriate weatherproofing of the system if used in an outdoor environment.

Safety Information

Warning

- To reduce the risks associated with hazardous voltage and fire:
  - Never use a non-approved battery or power supply. Approved options for powering the light include photovoltaic cell outputing 6V or less, USB micro cable, and/or a single cell Lithium ion battery. Use of non-approved power supplies can result in damage to the device, or result in the battery catching fire
  - Keep the product and the battery out of fire and water. Failure to do so may result in damage to the device or the battery catching fire.
  - Take care to never short circuit the battery terminals or puncture or otherwise damage the battery. If the wrapping around the battery is compromised, please use a different battery.
  - The LEDs on this device are high intensity. Do not stare directly at them while they are turned on. This includes the UV LEDs which do not appear as bright, but nevertheless can cause severe damage to the retina.

Smart-Trap Programmable Lighting Hardware

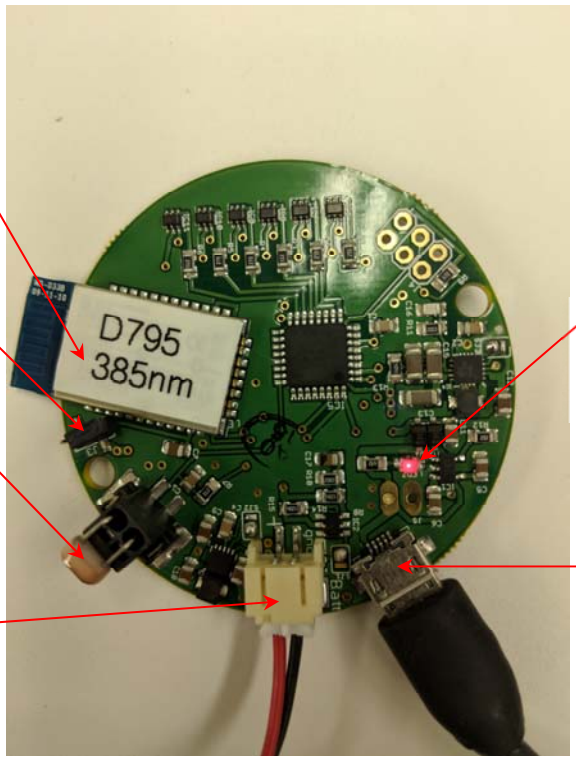
Figure 1. *Smart-Trap Programmable lighting device and peripheral components*

a) Bluetooth Radio (and Bluetooth Device ID- i.e.

b) 2mm header/ jumper to power Bluetooth

c) Photosensor/ Photoconductor

d) 2 mm JST jack for single cell Lithium battery input. Positive terminal (red) goes into the left side of jack.

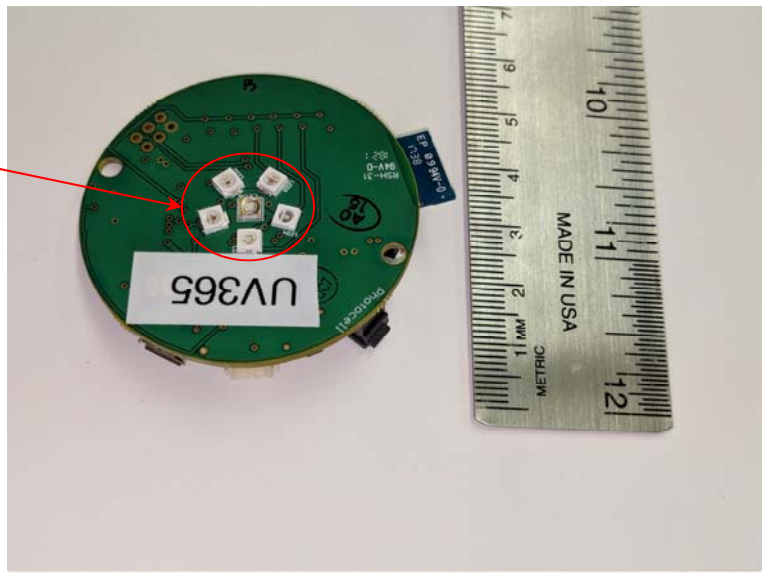


e) Battery charging indicator LED

f) micro-USB input (5V). Can be used with PV cells with USB power output.

Top of programmable lighting device.

g) LEDs (UV, Blue, Green, Yellow, Amber, and Red)



Bottom of programmable lighting device.

(1) Setting up the Smart-Trap lighting device.

Set up the Smart-Trap device in a dry location. If set up outdoors, additional precautions should be taken to ensure that the device and battery do not get wet (i.e. provide an enclosure / cover that prevents intrusion of water, and or coat with a conformal coating or other repelling material). If a conformal coating is used, it is recommended to first cover the LEDs with tape or some other material so that the light is not blocked by the coating.

Note that if the lights are enclosed in an enclosure with a transparent window, the "visible" wavelength LEDs will probably transmit through the window, but much of the UV may be blocked.

Power Options:

A micro-USB jack is provided on the board to provide one option for power. There is a separate 2mm JST jack intended for use with a single cell Lithium battery. The device will operate if power is supplied to either jack, and if both are used excess energy from the USB will be diverted to recharge the battery. Therefore, it is possible to operate the device autonomously in the field with a PV cell with USB output and battery storage. The power supply input and/ or USB are designed to recharge the battery, and the charging circuit will not deliver more than 500 mA to the circuit. When illuminated at full power each LED draws about 100 mA and the Bluetooth radio draws about 50 mA, so **the battery capacity and current rating for devices powering the circuit should be rated accordingly** based on the programmed settings (i.e. fully illuminating one LED on the device overnight for 12 hours would require a battery exceeding 1200 mA-hr in capacity.

If using a solar panel to recharge the device, the solar panel should ideally be placed in an unshaded location with a clear view to the sky. Tilt the panel towards the South (if in the Northern hemisphere) at an angle to the horizontal equivalent to the latitude where the trap is being used. A nominally 5W panel with USB output should be sufficient to charge a battery to run a single LED at full power over night if provided reasonable solar radiation during the day.

Once the Trap Lighting device is programmed with the desired settings, the power to the Bluetooth should be removed to prevent excessive drain on the device battery (See Section 6).

When conditions are such that LEDs are not operating according to the programmed settings, the controller goes into a low power mode and the device draws less than 1 mA current to save battery life. Therefore, sufficiently large batteries can operate the device for extended periods even without PV or other recharging, especially where LEDs are operated with light duty (i.e. a 2000 mA-hr battery should last about a week operating a single LED at full power for 2 hours per night, as long as the jumper powering the Bluetooth is removed).

Positioning the Photoconductor:

The microcontroller can be programmed through the Bluetooth to operate at a variety of diurnal cycles (see section 3, "*Diurnal Operation Settings*" below). The device determines whether it is day or night (and records the night duration each night) based on comparing a photodetector signal (Figure 1 c) to a pre-set threshold value. The photodetector (Figure 1 f) does not need to have a clear view of the sky, but it should be open to ambient light (i.e., not enclosed in a dark enclosure or otherwise occluded by close proximity to dark crevices, surfaces, or pockets). If operating under a dense canopy or other conditions where the daytime light is *very* dim (or if there are bright lights nearby during the night time), it is possible to reprogram the lighting threshold (see section 5 below). Usually it should not be necessary to reprogram the threshold as it is set at a

level corresponding to a twighlight transition (i.e. shortly after the official celestial sunset or before the sunrise) that is significantly lower than daytime light even in the shade, but still significantly higher than levels provided by most street and other lighting operated during the night. Note also that for servicing the device at night, brief periods (less than 5 minutes) of exposure to bright light during the night will not interrupt the device's timing of the night duration.

(2) Opening and Connecting the Trap Lighting App

Open the "Trap-Lighting" App on the Android Device (Figure 2).

Connect a standard 2mm jumper on the header to provide power to the Bluetooth radio (Figure 3). **If the jumper is not connected to the header, the Bluetooth will not be powered and you will not be able to communicate with the device. To connect to and reprogram the device, connect the jumper, and when finished programming remove the jumper and keep it in a safe place to prevent excessive drain on the battery from the Bluetooth radio.**

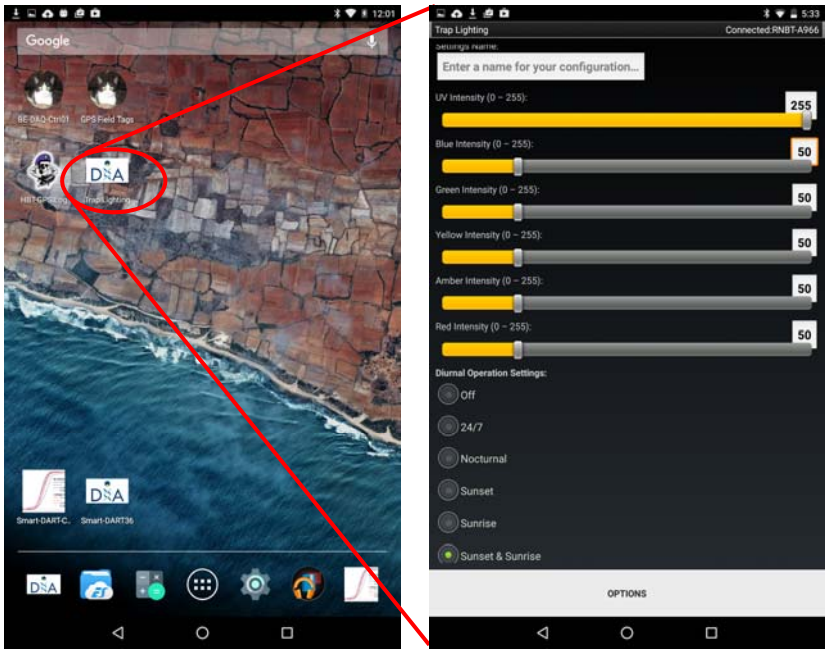


Figure 2. Open the Smart-Trap application in Android.

When the device's Bluetooth is powered, you can connect to it wirelessly from the Android app using the Connection Manager under "Options" at the bottom of the display (Figure 4). If you have already paired to the trap lighting before with the Android device you should be able to select the appropriate Bluetooth directly in the connection menu- if not you should be able to discover the device and connect to it by clicking "Scan for Devices" in the

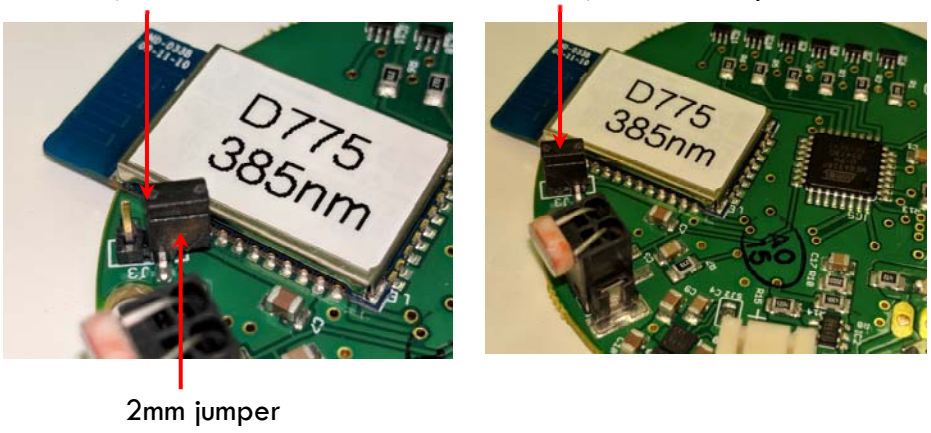


Figure 3. Place jumper on header to power Device Bluetooth.

connection menu. In some later versions of AndroidOS devices that have not previously been paired will not be discoverable within the app, so you will need to "pair" with them using the Android Bluetooth settings (Figure 5). Make sure to connect to the correct Bluetooth ID labeled on the Trap Lighting device (see Figure 1 h).

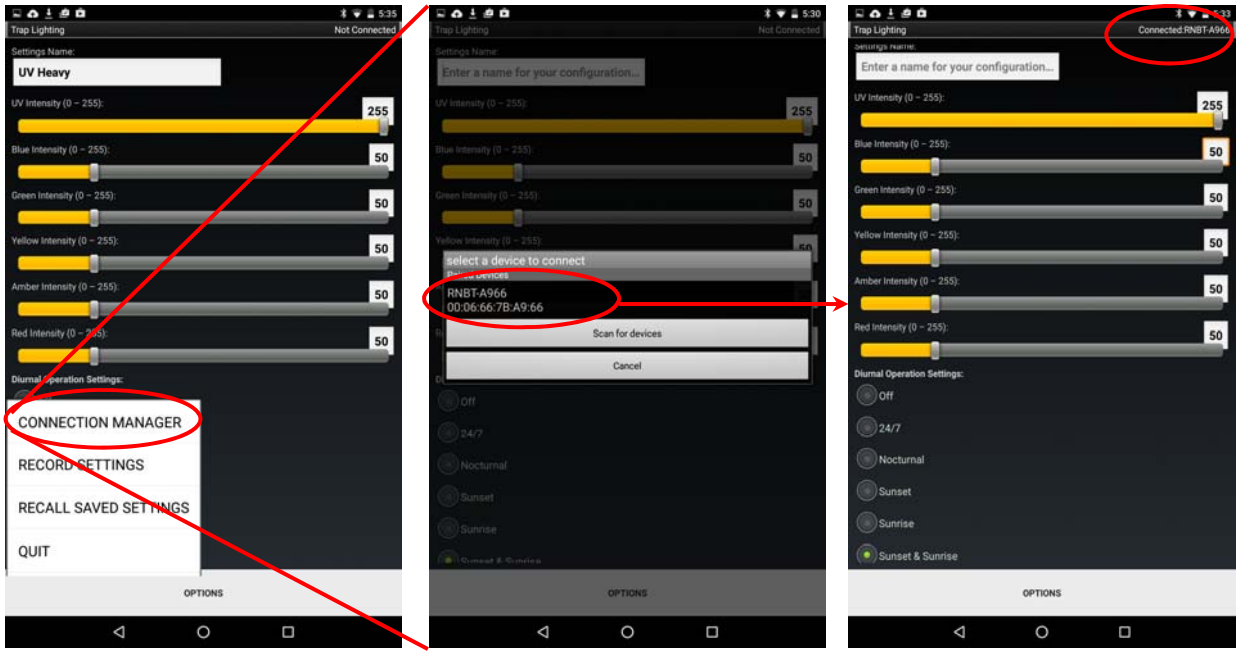


Figure 4. Connecting wirelessly to the Trap Lighting device from the Android App. If your connection is successful, the interface controls will display the settings currently programmed onto the device, and the top right of the title bar will show which Device ID the application is connected to.

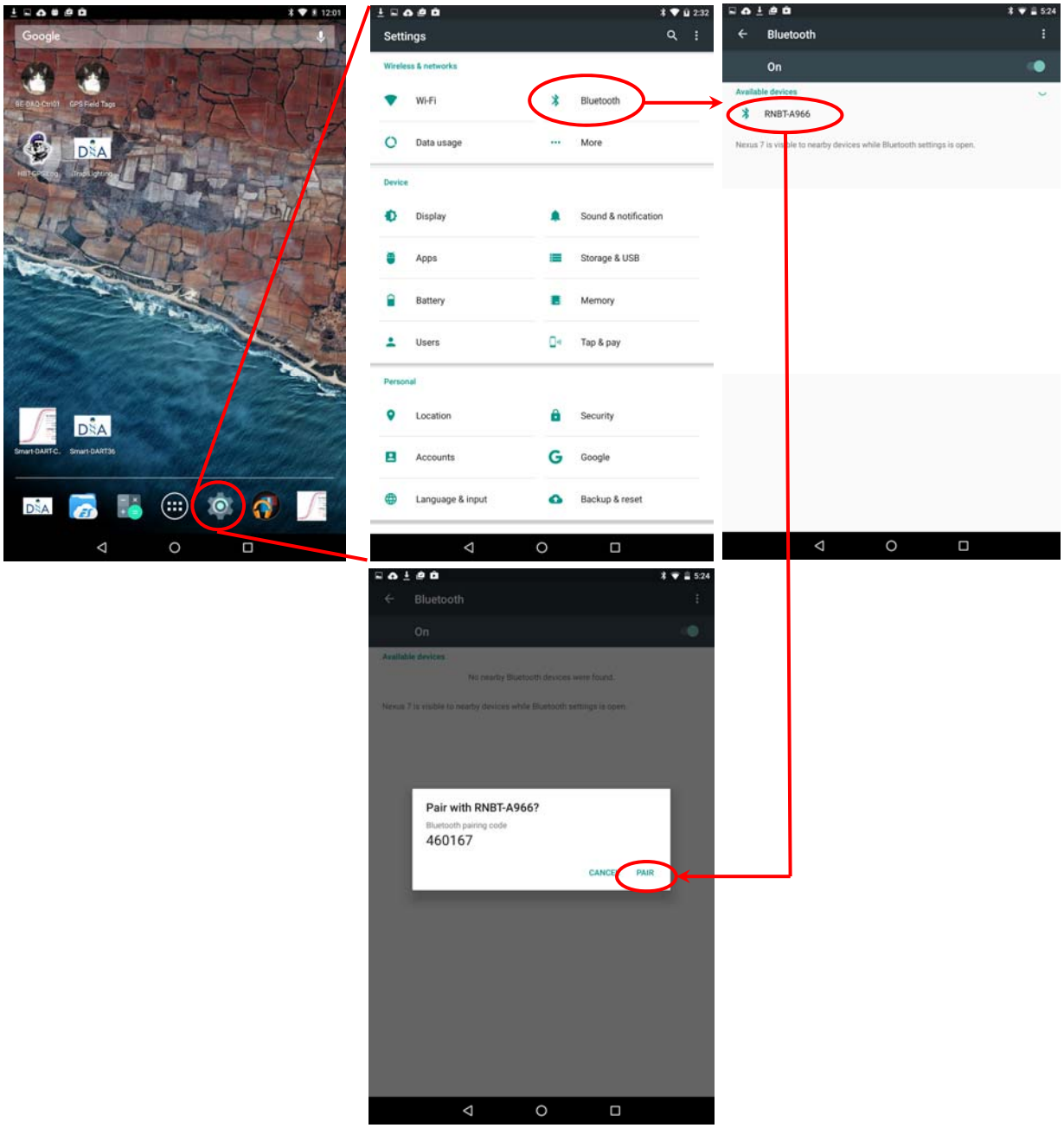


Figure 5. "Pairing" to the Trap Lighting device using the Android Bluetooth Settings (if device is not "discoverable" within the app as shown in Figure 4; Android Bluetooth Menu should automatically seek and populate itself with available Bluetooth devices in the area).

(3) (Re)Programming the settings on the Trap Lighting

When you first connect to the Trap Lighting Device, the controls will be populated with the settings currently programmed onto the device. You can adjust the device settings by interacting with the controls on the app interface (Figure 6). These controls should be relatively intuitive, and the settings will adjust automatically each time you change any parameter on the interface. **When you have adjusted the settings to the desired values, make sure to store the new settings into**

the devices non-volatile memory (Figure 7) or the device will revert to the previously saved settings the next time the power is cycled off and on.

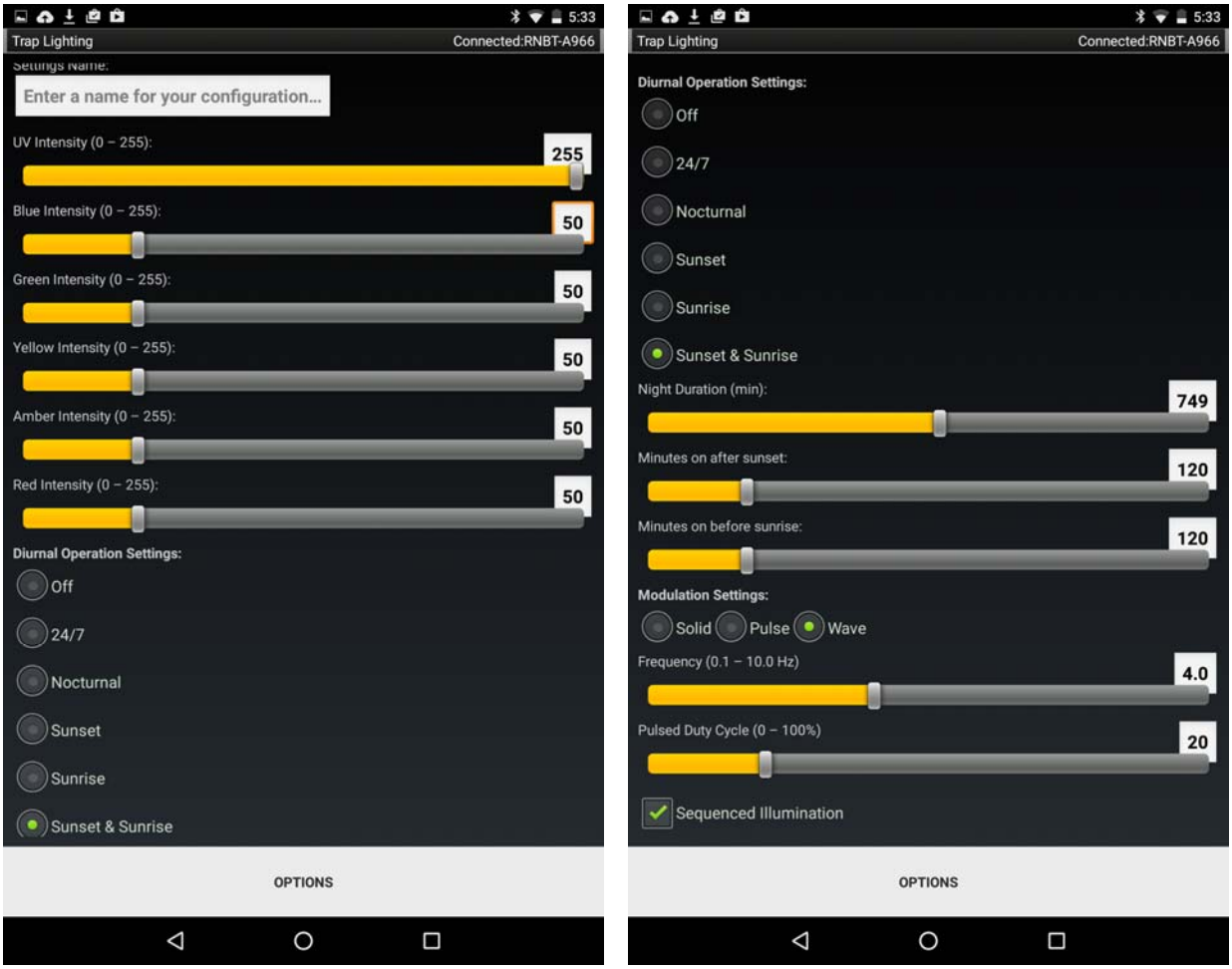


Figure 6. Dynamic controls for the Trap Lighting settings (you can scroll through all of the settings- left image is the top of the interface, right image is after scrolling all the way down).

- *Settings name:* User Defined name to store settings into a settings database on the Android (see section 4, Figure 8)
- *Intensities (UV, Blue, Green, Yellow, Amber, Red):* Maximum intensity of the respective LED. Intensity is controlled by pulse width modulation at about 500 Hz, through an 8 bit match register, with 255 corresponding to maximum available intensity or 100% duty cycle. Any LED set to 0 intensity is not included in "sequenced" rotation of "pulse" or "wave" modulation (see corresponding settings below)
- *Diurnal Operation Settings:* Options are "Off" (LEDs always off); "24/7" (selected LEDs are always activated with the selected modulation settings); "Nocturnal" (selected LEDs are active throughout the night); "Sunset" (selected LEDs are active for a selected number of minutes after sunset); "Sunrise" (selected LEDs are active for a selected number of minutes prior to sunrise), and; "Sunset & Sunrise" (selected LEDs are active for the selected numbers of minutes after sunset and before sunrise).

- *Night Duration:* The time in minutes between sunset and sunrise at the current location (used to predict the sunrise based on observed sunset; this value will be overwritten automatically if the device observes a recognizable duration of one night, with the newly observed duration). Note that the ambient light threshold is set at a level typical of twilight, so "night duration" will usually be somewhat shorter than the interval between the official celestial sunset and sunrise.
- *Minutes on After/ Before Sunset/ Sunrise:* self explanatory- only used under "Sunset", "Sunrise", and/or "Sunset & Sunrise" diurnal settings.
- *Modulation Settings:* When ambient lighting and/or diurnal setting indicates light should be activated: "Solid" turns on all LEDs at a constant value of their respective selected intensities; "Pulse" blinks the selected LEDs on and off with the frequency and duty cycle set in those corresponding controls, and; "Wave" cycles the intensity of each LED from 0 to the "intensity" value and back to 0 in a sinusoidal fashion.
- *Frequency:* The frequency (in Hz) of modulation for "Pulse" or "Wave" modulation (disregarded for "Solid" modulation setting).
- *Duty Cycle:* The duty cycle for "Pulse" modulation (disregarded for other modulation settings).
- *Sequenced Illumination:* When checked and modulation is not "Solid", individual LEDs will be modulated according to the selected modulation settings in sequence (i.e., one at a time, one following another, but omitting any "0" intensity LEDs from the cycle). When unchecked, all of the non-0 intensity LEDs will illuminate simultaneously with the given modulation scheme.

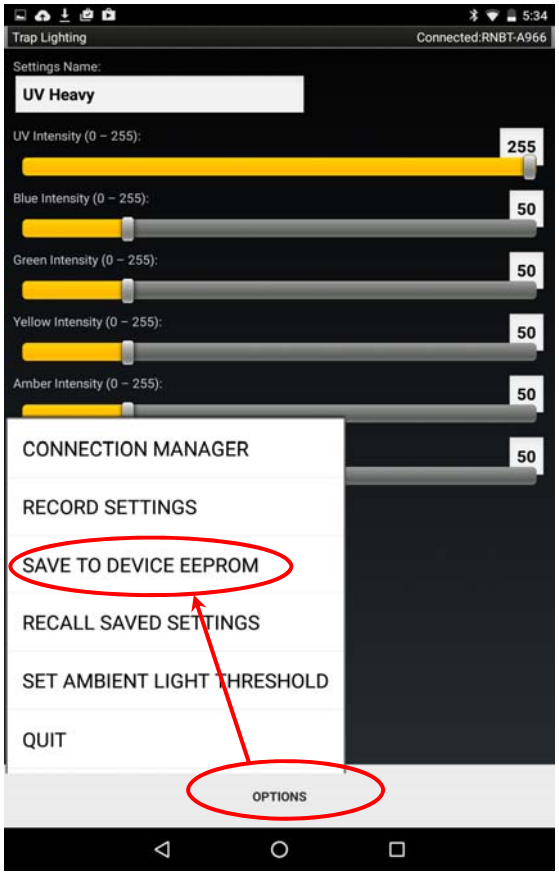


Figure 7. Save current settings to Trap Lighting non-volatile memory (failure to execute this step will result in the device reverting to the previously stored settings the next time that power is cycled off and on).

(4) Saving and recalling settings on the Android app

If programming numerous Trap Lighting circuits with similar settings, it can be useful to save and recall settings from a database within the Android app (Figure 8).

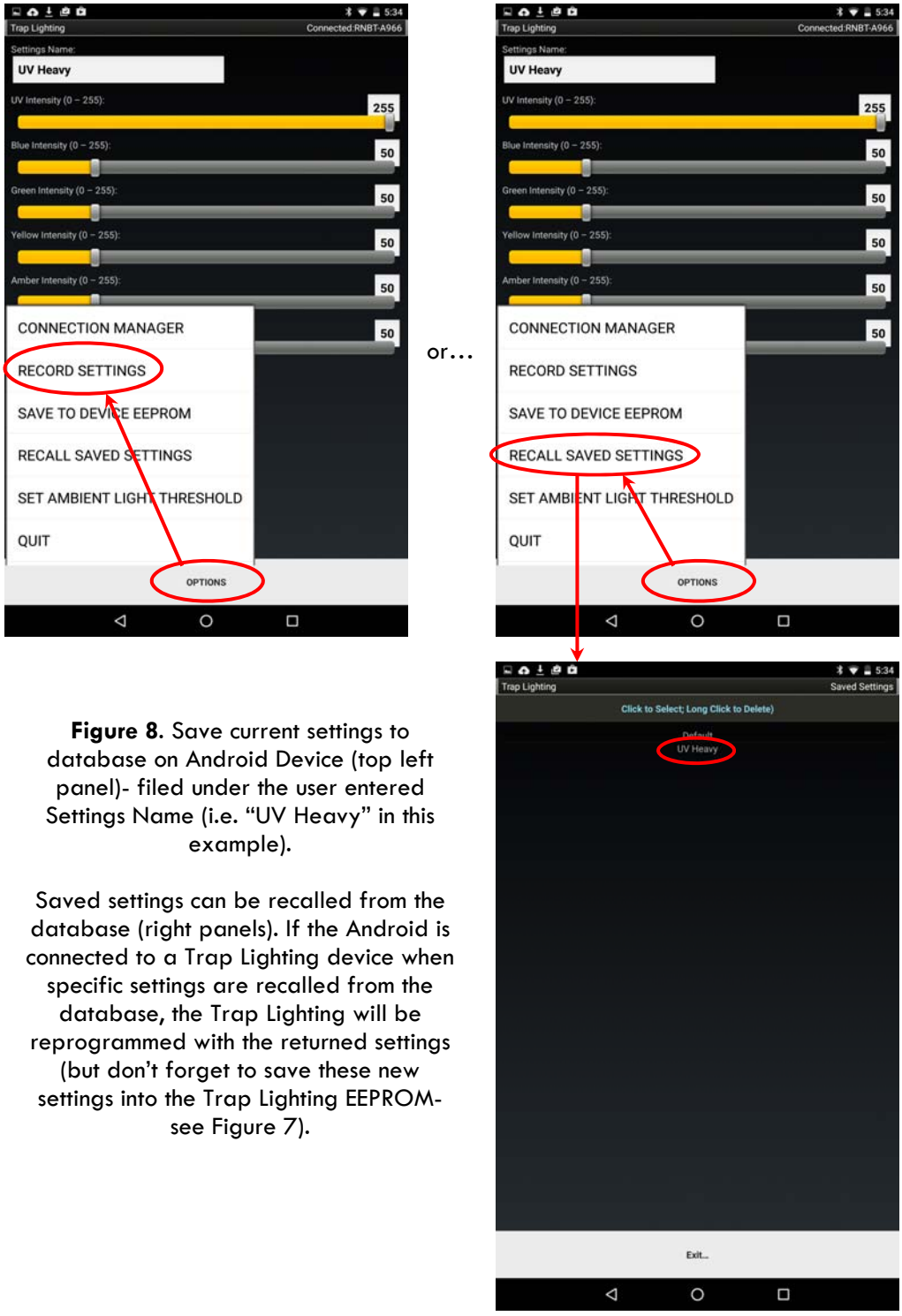


Figure 8. Save current settings to database on Android Device (top left panel)- filed under the user entered Settings Name (i.e. "UV Heavy" in this example).

Saved settings can be recalled from the database (right panels). If the Android is connected to a Trap Lighting device when specific settings are recalled from the database, the Trap Lighting will be reprogrammed with the returned settings (but don't forget to save these new settings into the Trap Lighting EEPROM- see Figure 7).

(5) Reprogramming the ambient light threshold

The Trap Lighting has a connector for a photoconductive sensor (Figure 1 f), and the device compares the signal from this device to a programmed threshold to determine whether it is day or night to control the diurnal operation appropriately. The pre-programmed threshold is set to a "twighlight" level of ambient lighting that is significantly higher than illumination levels provided by typical street lighting at night, but significantly lower than ambient light in the daytime even in the shade. If this is not the case you can reprogram the threshold by putting the photosensor in light conditions representative of the desired threshold, and selecting "Set Ambient Light Threshold" in the "Options" menu (Figure 9).

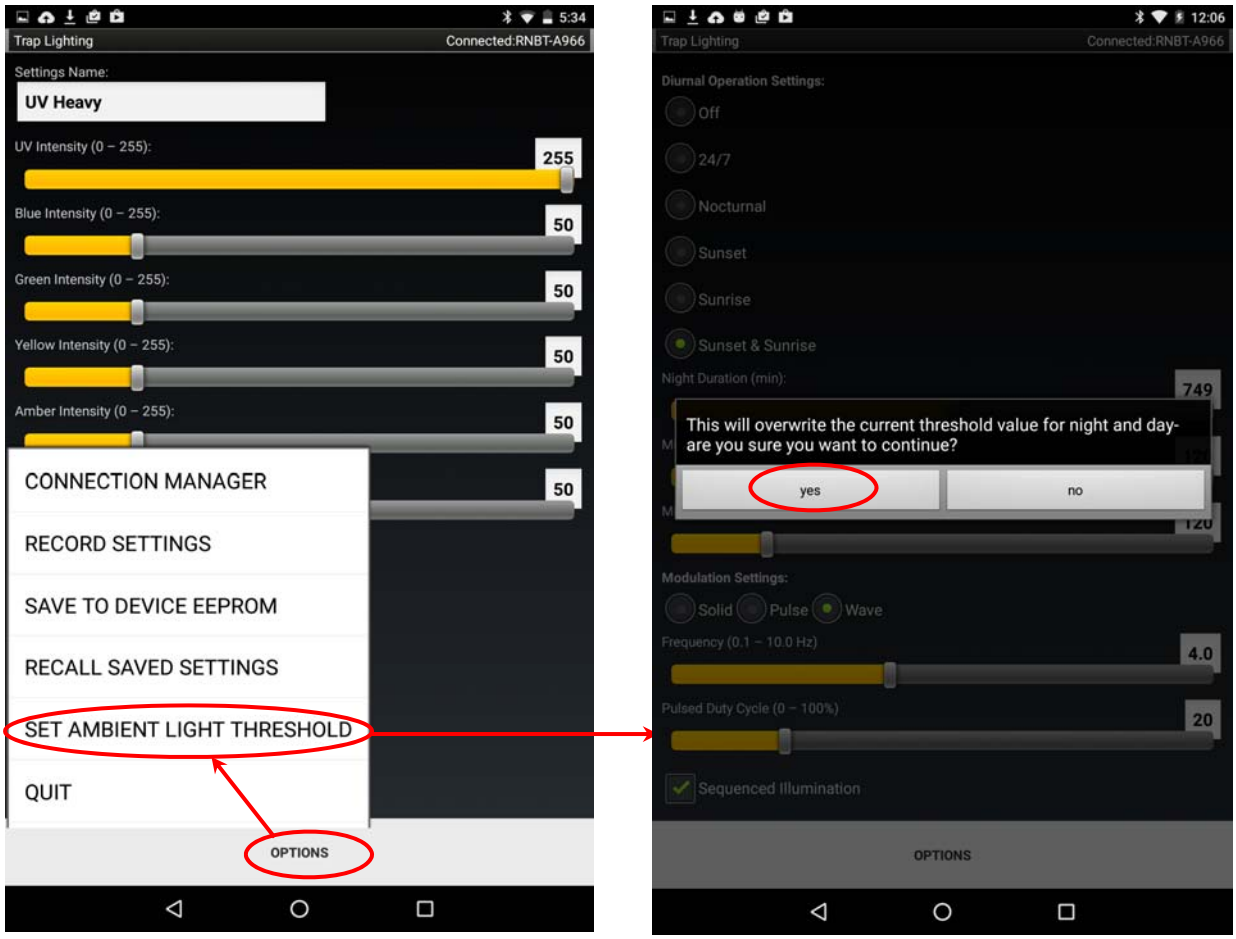


Figure 9. Reprogramming the ambient light threshold on the Trap Lighting to discriminate day and night.

(6) Disconnecting and Powering Down Bluetooth

The Bluetooth device on the Trap Lighting consumes 50 mA of current while in discoverability mode- and so will completely deplete the provided battery within 14 hours if left on. Therefore it is strongly recommended that power be removed from the Bluetooth once it is programmed to the desired settings (and the settings are "Saved to EEPROM" i.e. Figure 7). Once you have programmed it, disconnect from it in the app (under "Options" click " Connection Manager" and then "Disconnect"). Once the Bluetooth is disconnected, remove the jumper providing power to the Bluetooth on the Trap Lighting (reverse of Figure 3), and set it aside in a safe place so that the device can be reprogrammed in the future.

(7) Contact information

For questions or technical support, contact Daniel M. Jenkins at (808) 781-1343.