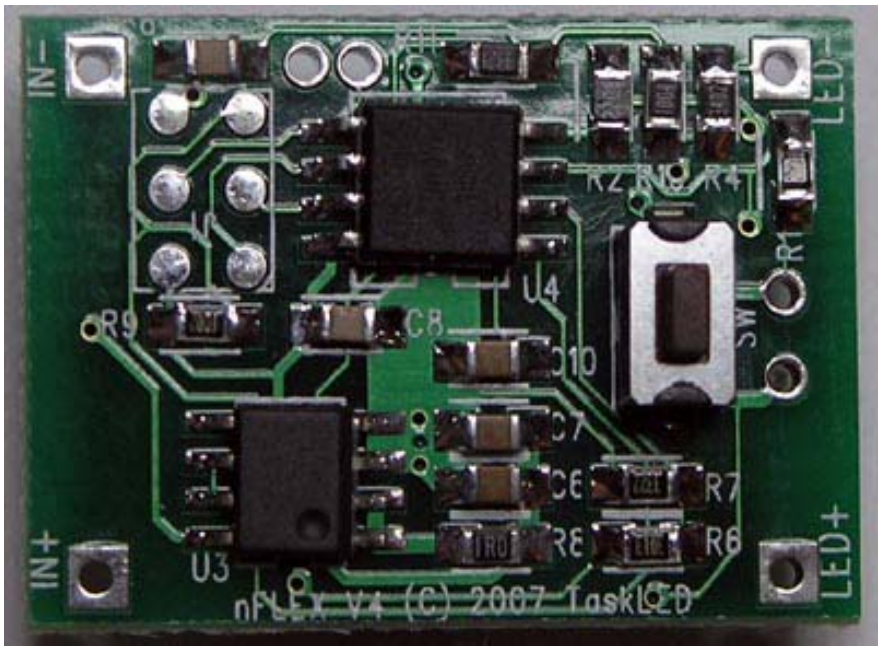
Operating Manual for nFlex UIB2 (V1.01a)

1. Description

The heart of nFlex is a Microcontroller (uC) that contains the user interface firmware. Features of this circuit/UI combination include:

- Optimized **Bicycle** lighting User Interface (UI).
- High efficiency step down switching regulator (maximum drive current set in firmware).
- Single switch to select from various brightness levels, turn the unit on/off, select the operating modes, and set Menu options.
- Non-volatile (EEPROM) storage of operating mode, last selected brightness level, and maximum drive level (350 mA, 500 mA, 750 mA or 1000 mA).
- Voltage sensing with two user configurable trip points for ½ discharged and nearly fully discharged. Warning display via an optional 3mm or 5mm status LED or via the main LED.
- Temperature sensing with user configurable trip point to limit output current to protect the driver and/or LED.

1.1 Wiring nFlex



The picture shows the connections to nFlex. The user provides DC power to the nFlex (via battery, DC wallwart, vehicle/boat/RV 12 V). nFlex is reverse polarity protected.

nFlex has a switch included (not soldered in case the user does not require it) with the board. An additional switch may be connected via leads soldered to the holes SWA and SWB. The switch needs to be a momentary action, push to close type, i.e. normally open contacts.

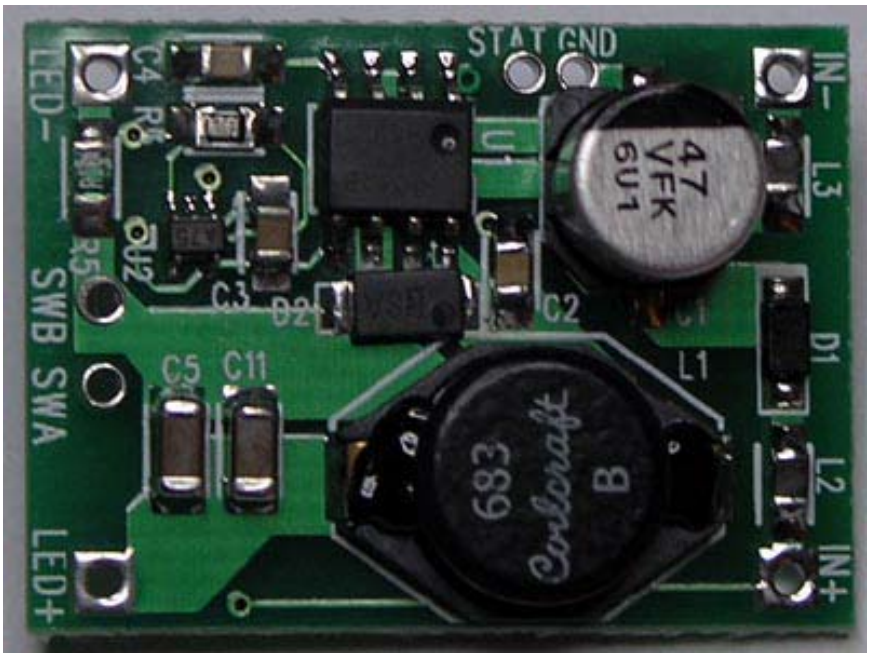
Input power is connect via IN+ (positive input voltage) and IN- (negative input voltage).

The LED load is connected to LED+ (positive LED) and LED- (negative LED). NOTE: LED- is NOT the same as IN-.

An optional 3mm or 5mm colored LED can be connected between STAT (anode) and GND (cathode) to be used as a battery status indicator. It is recommended to use a series resistor in the 50 ohm range in series with the STAT LED to reduce and limit the current. Nominal drive voltage is 3.3V.

Temperature sensing is performed within the uController, the 8 pin IC in the top center of the PCB in the picture above.

Below is the view of the other side of the nFlex board.



The following table shows the supported configurations of nFlex.

Driver Configuration	Input voltage for regulation (min)*	Input voltage Operating (min)**	Input voltage (max)
1 to 5 1 W LED (in series)	ΣVfn+0.7 V	4 V	24 V
1 to 5 3 W LEDs (in series)	ΣVfn+1.1 V	4 V	24 V
1 to 3 5 W LED	ΣVfn+1.1 V	4 V	24 V

* Nominal Minimum input voltage to ensure current regulation is maintained. Below this voltage nFlex will enter direct drive and the brightness will drop. If lower light levels are selected, nFlex may be able to keep the LED in current regulation due to lower Vf requirements at lower current. These dropout voltages assume that the input protection diode is shorted out.

Vf is the forward voltage of the LED at the driven current.
ΣVfn is the sum of the forward voltage of all the series connected LEDs.

** Minimum operating voltage for nFlex.

2. Definitions

- CLICK – a short, less than 0.3 seconds press and release.
- PRESS – a longer, greater than 0.3 seconds press and hold.
- Force – an option to always have the light turn on at a specific user-selected level.
- UI – User Interface.
- EEPROM – non-volatile memory. Stored data will remain even if battery is disconnected.
- LED – Light Emitting Diode. As used here, it typically refers to the light's main LED(s).

3. Turning the light ON the first time

Do not apply power to nFlex unless an LED is connected. This is to protect the LED from voltage spikes if it is connected to nFlex after power has been applied.

nFlex is shipped with the lowest drive level (350 mA) selected, and Poweron mode turned on. When power is first applied, nFlex will safely drive the LED at the lowest level.

3.1 Initial Power Application

Upon initial power application to the circuit, the main LED will flash quickly and dimly for three seconds to indicate that the "Menu entry window" is open. If three seconds pass with no button action, the LED will light (because Poweron Mode is active by default) at the lowest level. The circuit is on and ready to use.

The STAT LED (if connected) will also flash momentarily as a self test. The same test flash will be seen when turning the light on via a click (constant mode) or press (strobe mode).

4. Overview of the User Interface (UI) and the Control Menu.

4.1 Bicycle (UIB2) Operation Overview

Intended for bicycle lighting. Separate modes for constant and strobe (two or five levels each). From off, a click turns on to constant mode, and a long press turns off. From off, a press turns on to strobe mode, and a long press turns off. Constant and strobe modes are identical in operation and Menu choice – except for the click or press to enter the individual modes. In the 2-level Duomode, brightness changes are controlled by clicking to toggle between the two chosen levels. In 5-level Multimode, clicking increases brightness and pressing decreases brightness.

4.2 Menu features/choices Overview

Bold is the shipping default setting.

1. Force Level (choose level for initial on, or **disable**)
2. Current Drive Level (**350ma**, 500 mA 750 mA, 1000 mA - all intermediate brightness levels scale to this max level)
3. Duomode (L1, **L2**, L3, L4, disable)
4. SuperLock (**disable,** enable)
5. V Stat (how often the LED warns that V Low and V Med levels have been reached. Flash sequence per 5, 10, 30, 60 seconds, or **disabled** - STAT pin only)
6. V Low (protect rechargeable batteries by setting a high-alert warning flag at a chosen Voltage level. Enter in form xy.z) Default: **13.0 V** (configured for 14.4V Li-Ion battery)
7. V Med (Warn of battery half discharged. Enter in form xy.z) Default: **14.3 V** (configured for 14.4V Li-Ion battery)
8. Power On (disable, **enable** “on” function when power is applied)
9. Thermal Protection (trip point that reduces power to L3 if the system is at risk of overheating. 50°C, 60°C, 70°C, 80°C, 90°C, **disable**)
10. Reset (Menu selections reset to shipping defaults)

Note: Snip and save the above Menu table for quick reference.

5. UIB2 (Bicycle Optimized User Interface) - Constant and Strobe.

The various operating modes of UIB2 are described below. Please note that ALL operations are identical in constant and strobe modes – except for the click or press to enter those modes.

5.1 On/Off Mode (non Superlock)

5.1.1 In Duomode (default)

a. Constant Mode: A click turns on the light and further clicks toggle between low (L2 by default) and high (L5). From on, a press will turn off the light after a “safety delay” of about two seconds.
b. Strobe Mode: A press will turn on and subsequent clicks will toggle from low strobe (L2 by default) and high strobe (L5). From on, a press will turn off the light after a “safety delay” of about two seconds.

5.1.2 In Multimode (Duomode disabled)

a. Constant Mode: A click turns on at the previous level (or at Force Level if set), and further clicks brighten up to L5. Subsequent clicks will flash the LED to indicate that L5 has been reached. From on, a press will dim down to L1 (the LED will flash to warn that L1 has been reached). Continuing to press will turn off the light after a short “safety delay.”
b. Strobe Mode: A press turns on at the previous level. Once on, clicks increase the brightness level up to L5. Subsequent clicks will flash the LED to indicate that L5 has been reached. From on, a press will dim down to L1 (the LED will then blink once to indicate that L1 has been reached). Continuing to press will turn off the light after a short “safety delay.” To simplify choosing the desired brightness level in strobe mode, when the button is clicked or pressed the LED will go into constant mode for 1.5 seconds and then revert to strobe mode at the newly selected level. In other words, all level changes in strobe mode will be shown in constant mode before strobe resumes.

5.2 Adjustment Mode

5.2.1 In Duomode (default)

Constant & Strobe Modes: From on, clicking toggles between low and high. The brightness of low is chosen in the Duomode Menu (Sec 6.3). High is the selected Drive Current (Sec 6.2).

Each time the brightness level is changed the new level is stored in EEPROM ready to be retrieved the next time the unit is turned back on.

5.2.2 In Multimode (Duomode disabled)

a. Brighter, Constant & Strobe Modes: From on, clicking cycles up through the five available levels. If L5 (highest) has been reached and the user clicks the button again, the LED will flash to indicate that the maximum level has already been reached.
b. Dimmer, Constant & Strobe Modes: From on, pressing cycles down through the five available levels. When L1 (lowest) has been reached, the LED will blink to indicate that the minimum level has been reached. If L1 is the desired level, release the button. (If off is desired (Sec 5.1), continue to press the button and the light will turn off after a brief “safety delay.”)

Note: In strobe mode, a click or press will temporarily exit strobe mode and enter constant mode to simplify the visual selection of the strobe level. 1.5 seconds after the last click, the LED will again strobe.

The five levels are factory-set and levels L2-L5 scale with the Current Drive Menu option (Sec 6.2). L1 in all current tables is set to approximately 45 mA for longest runtime.

Each time the brightness level is changed, the new level is stored in EEPROM ready to be retrieved next time the unit is turned back on.

5.3 Superlock Mode

To prevent accidental turn on or unintended use, the light can be electronically locked off. If Superlock is enabled, each time the user wants to turn the light on, 2 clicks spaced no more than 0.3 seconds apart must occur prior to the click or press that turns the light on (constant or strobe respectively).

In other words, to turn the light on with Superlock enabled:

a. To Constant Mode: The user clicks three times, no more than 0.3 seconds apart.
b. To Strobe Mode: The user clicks twice and presses, no more than 0.3 seconds apart.

6. Menu Selection (Configuring operation)

This section describes how to enter the Menu system and how to change operating options. All changes are stored in the EEPROM. Every Menu option modifies the operation of both modes - strobe and constant.

To access the Menu, remove power (disconnect the battery) from the circuit and then re-apply power. A dim, rapid flash sequence from the LED will indicate that the “Menu entry window” is open (the window is open for three seconds). Within 3 seconds of applying power PRESS (not click) the button and the LED will flash brightly 2 times, then stay steady dim to indicate that the Menu system has been entered.

Note: During the 3 second “Menu entry window” and while in the Menu system, voltage sensing and temperature sensing is disabled.

Click the switch from 0 to 10 times (the LED will flash a response for each click, do NOT try to beat the flash) to select one of the Menu options to change as listed below. To exit the Menu system, press the switch. The LED will flash 2 times and then the light will turn off. To re-enter the Menu system you will need to remove/reapply power as described above.

If any errors occur in selecting a Menu option (e.g. clicking more than 10 times or making an invalid selection), the LED will flash quickly 5 times to indicate an error and the user will be returned to the top of the Menu system as if it had just been entered.

If at any time you lose track or get confused about where you are in the Menu system, you can always remove power and only the settings that have been altered (if any) will have been written to the EEPROM.

After clicking from 0 to 10 times to select the Menu entry, press the switch.

Example – set drive current to 750 mA:

1. Disconnect and reconnect power to the circuit. The LED will flash rapidly.
2. Within three seconds, press the button. The LED will flash brightly two times and stay steady dim. You are in the Menu system.
3. Click twice to choose the Current Drive Selection (wait for flash response after each click).
4. Press to select this option. The LED will light steady dim. You are in the *Current Drive Selection* at the lowest option, 350 mA.
5. Clicking once will make the LED brighter, indicating 500 mA. Clicking a second time brightens the LED again, indicating 750 mA.
6. Press to save your selection. The LED will flash twice and stay steady. You have now saved the 750 mA Current Drive Selection, and are back to the top of the Menu.

   If that is all you would like to set, press one more time to exit the Menu. Two flashes later, you are out of the Menu and into the normal operation mode. If instead you would like to set another Menu option, do not press, and go back to step three above and click the proper number of times for your next selection.

6.1 Zero clicks – Nothing

This option changes nothing and allows the user to exit the Menu system.

Initially the LED will be dim to indicate that the Menu system has been entered. If no (further) Menu changes are needed, a press will exit the Menu system (2 flashes). The light turns off and is ready to use.

6.2 One click - Force Mode Enable/Adjust/Disable

This mode overrides the last-used level. Force Mode is ignored when Duomode is enabled.

Initially the LED will be dim to indicate that Force Level 1 (dimmest) will be selected (i.e. if you don't click, Force will become active and set to Level 1). Each click will cycle to the next Force setting. The sequence is:

- 0 click (actual L1) → Force Level 1 select
- 1 click (actual L2) → Force Level 2 select
- 2 click (actual L3) → Force Level 3 select
- 3 click (actual L4) → Force Level 4 select
- 4 click (actual L5) → Force Level 5
- 5 click (off) → Force Disabled (last-used level will be used) - default

The LED brightness matches the actual L1 – L5 brightness levels. When you are satisfied with the choice, press to save the setting. The LED will flash twice to indicate that the selection has been made and then go dim to indicate that it has returned to the Menu mode for the next selection.

6.3 Two clicks – Current Drive Selection

The circuit can be set to one of four maximum current drive levels. This selection will be L5 or "high" for all modes. The brightness scales of all other levels are determined by this setting.

Initially the LED will be dim to indicate that 350 mA max current will be active. Each click will cycle to the next current drive level and wrap back to the beginning. The sequence is:

- 0 click (dim) → 350 mA select - default
- 1 click (brighter) → 500 mA select
- 2 click (brighter) → 750 mA select
- 3 click (brightest) →1000 mA select

When you are satisfied with the choice, press to save the setting. The LED will flash twice and go dim to indicate that the selection has been made, and that the Menu mode has been reentered.

6.4 Three clicks – Duomode Enable/Disable

The circuit can be configured to operate in either a simple 2 level mode (Duomode) or a more elaborate and flexible 5 level mode (Multimode). The force setting (Sec 6.2) will be ignored if Duomode is enabled.

Initially the LED will be dim (actual L1 in this case) to indicate that L1 is chosen. Each click will cycle to the next choice and wrap back to the beginning.

- 0 click (actual L1) → Duomode low level L1 select
- 1 click (actual L2) → Duomode low level L2 select - default
- 2 click (actual L3) → Duomode low level L3 select
- 3 click (actual L4) → Duomode low level L4 select
- 4 click (off) → Duomode disabled, Multimode enabled

When you are satisfied with the choice, press to save the setting. The LED will flash twice to indicate that the selection has been made and then go dim to indicate that it has returned to the Menu mode for the next selection.

6.5 Four clicks – Superlock Enable/Disable

To prevent accidental turn on or unintended use, the light can be electronically locked off. With Superlock enabled, each time the user wants to turn the light on, 2 clicks spaced no more than 0.3 seconds apart must occur prior to the click or press that turns the light on (constant or strobe respectively).

Initially the LED will be dim to indicate that Superlock Mode will be disabled (i.e. if you don't click, Superlock Mode will be disabled). A click will brighten the LED to indicate that Superlock Mode will be enabled. Each click will cycle between enabled and disabled.

When you are satisfied with the choice, press to save the setting. The LED will flash twice and go dim to indicate that the selection has been made, and that the Menu mode has been reentered.

6.6 Five Clicks – Voltage Warning Status

How (and how often) the circuit reports the low and medium voltage conditions is configured using this Menu option.

The circuit reports the low voltage condition via the STAT pin on the PCB. STAT will drive high (~3.3V) to light the status LED and drive back to 0V to turn the status LED off. The STAT pin can drive a single 3mm or 5mm (at approximately 20 mA). If this feature is used, wire the 3mm or 5mm LED between STAT and GND, use a resistor of approximately 50 ohms in series with the LED (either the anode or cathode). A red or amber LED is recommended for this use.

Note: The STAT pin will light the status LED (if affixed) if the input voltage is greater than the V Low Setting but less than the V Med Setting. The STAT pin will pulse (flash the status LED) once per second when the input voltage is less than the V Low Setting.

The STAT pin is pulsed once every time the light is turned on as a self-check that the status LED is functioning correctly.

If the user does not want to wire a status LED to the STAT pin but still wants an indication of low voltage occurring, then the main LED can be set to flash at a specific interval to give a visual warning. How the main LED flashes is dependent on whether the light is in constant or strobe mode.

Constant Mode: If the input voltage is greater than the V Low Setting but less than the V Med Setting, the main LED will briefly flash off once at the flash rate chosen with this Menu option (5 sec, 10 sec, 30 sec or 60 sec). This warning will time out after five sequences so the remaining battery capacity can be used without annoyance. As a reminder, the V Med warning sequence will repeat if the light is turned off/on, or if a higher level is chosen. The STAT pin will remain active with no timeout. If the input voltage is less than the Low Setting the main LED will flash off twice at the flash rate. This V Low warning sequence will continue until the battery is depleted or recharged to above the V Med Setting. These sequences were chosen to give an obvious indication of battery status while still allowing use of the light for navigation.

Strobe Mode: If the input voltage is greater than the V Low Setting but less than the V Med Setting, the main LED will do a slower strobe sequence for ~1 second at the flash rate chosen with this Menu option (5 sec, 10 sec, 30 sec or 60 sec). This sequence will occur five times as a warning, and then time out so as not to be annoying during use. As a reminder, the V- Med warning sequence will repeat if the light is turned off/on, or if a higher level is chosen. If the input voltage is less the Low

Setting the main LED will do a faster strobe sequence for ~1 second at the flash rate. This V Low warning sequence will continue until the battery is depleted or recharged to above the V Med Setting. These sequences were chosen to give an obvious indication of battery status while still allowing use of the light for navigation.

Initially the LED will be Dim to indicate that one flash per 5 seconds will be chosen. See the table below for all available settings.

- 0 click (dim) → Main LED flash once per 5 sec (undervoltage)
- 1 click (brighter) → Main LED flash once per 10 sec (undervoltage)
- 2 click (brighter) → Main LED flash once per 30 sec (undervoltage)
- 3 click (brighter) → Main LED flash once per 60 sec (undervoltage)
- 4 click (off) → No Main LED flash for undervoltage - default

When you are satisfied with the choice, press to save the setting. The LED will flash twice and go dim to indicate that the selection has been made, and that the Menu mode has been reentered.

Note: regardless of the selection for this Menu, the STAT pin will always report the battery status.

6.7 Six Clicks – Voltage Warning Low Setting

The circuit can be configured to warn the user when low input voltage occurs. The user can set the voltage warning to any value between 0V – 20V. The voltage value is entered by setting a number in the format: xy.z (e.g. 06.8V).

The V Low setting is the value that the user chooses to protect the battery pack from over discharge. Of course the warning can be ignored if necessary (emergency), though the warning will never time out.

Initially the LED will be dim, waiting for entry of the ‘x’ (tens). Click 0 to 2 times (If you don’t click, 0 will be selected for the tens digit).

When you are satisfied with the choice, press to save the setting

The LED will dim again and wait for entry of the ‘y’ (units). Click 0 to 9 times (If you don’t click, 0 will be selected for the units digit

When you are satisfied with the choice, press to save the setting

The LED will dim again and wait for entry of the ‘z’ (tenths). Click 0 to 9 times (If you don’t click, 0 will be selected for the tenths digit

When you are satisfied with the choice, press to save the setting. The LED will flash twice and go dim to indicate that the selection has been made, and that the Menu mode has been reentered.

The xy.z value is stored in the EEPROM and can be changed by following the above procedure as often as necessary.

Note: the circuit senses the input voltage across IN+ and IN-. This means that measured voltage for the Voltage Warning circuitry is quite accurate.

6.8 Seven Clicks – Voltage Warning Medium Setting

The circuit can be configured to warn the user when medium input voltage occurs. The user can set the voltage warning to any value between 0V – 20V. The voltage value is entered by setting a number in the format: xy.z (e.g. 06.8V).

The V Med setting is the value that the user chooses to indicate that the battery is around half discharged (recommendation). Of course the user can set this to whatever value he/she chooses. This warning will time out after five sequences so the remaining battery capacity can be used without annoyance. As a reminder, the V Med warning sequence will repeat if the light is turned off/on, or if a higher level is chosen. The STAT pin will remain active with no timeout.

Initially the LED will be dim, waiting for entry of the ‘x’ (tens). Click 0 to 2 times (If you don’t click, 0 will be selected for the tens digit).

When you are satisfied with the choice, press to save the setting

The LED will dim again and wait for entry of the ‘y’ (units). Click 0 to 9 times (If you don’t click, 0 will be selected for the units digit

When you are satisfied with the choice, press to save the setting

The LED will dim again and wait for entry of the ‘z’ (tenths). Click 0 to 9 times (If you don’t click, 0 will be selected for the tenths digit

When you are satisfied with the choice, press to save the setting. The LED will flash twice and go dim to indicate that the selection has been made, and that the Menu mode has been reentered.

The xy.z value is stored in the EEPROM and can be changed by following the above procedure as often as necessary.

Note: the circuit senses the input voltage across IN+ and IN-. This means that measured voltage for the Voltage Warning circuitry is quite accurate.

6.9 Eight clicks – Poweron Mode Enable/Disable

The circuit can be configured to either power-up with the LED lit or unlit when power is first applied. E.g. In a light fixture that has an auxiliary power switch in series with the battery and the circuit, the user can choose to have the circuit illuminate the LED as soon as the power switch is turned on (after the menu-entry window has closed). In this case the user would Enable Poweron Mode.

Initially the LED will be dim to indicate that Poweron Mode will be disabled (i.e. if you don’t click, Poweron Mode will be disabled). A click will brighten the LED to indicate that Poweron Mode will be enabled. Each click will cycle between enabled and disabled.

When you are satisfied with the choice, press to save the setting. The LED will flash twice and go dim to indicate that the selection has been made, and that the Menu mode has been reentered.

6.10 Nine Clicks – Thermal Protection

To protect the light from over-heating, a thermal trigger point can be set with this option. Obviously the temperature sensing will not be of any use in a light that has the LED heatsink/case far from the driver.

When the internal thermal sensor detects the configured temperature, the light level is dropped to L3 in Multimode, or the chosen "low" level in Duomode (or to L3 if Duomode low was chosen as L4). The user will not be able to access levels above L3 until the temperature has dropped a minimum of 5°C. At that time, full operation of the light is restored. Note: The sensor determines the temperature of the IC, not of the light case, the LED junction, etc.

Initially the LED will be dim to indicate that 50°C is chosen. Each click will cycle to the next temperature option and wrap back to the beginning. The sequence is:

- 0 click (dim) → 50°C
- 1 click (brighter) → 60°C
- 2 click (brighter) → 70°C
- 3 click (brighter) → 80°C
- 4 click (brightest) → 90°C
- 5 click (off) → disabled (default)

When you are satisfied with the choice, press to save the setting. The LED will flash twice and go dim to indicate that the selection has been made, and that the Menu mode has been reentered.

HINT: Choosing the appropriate temperature for a particular light will require some trial and error if temperature measurements of the case and thermal sensing IC aren't possible, e.g. due to lack of equipment. One way to do this is to allow the case to warm up to a temperature that is beyond your comfort level. Set the temperature trip point (below) to 90°C and then turn the light on normally and see if the thermal protection activates. If it doesn't activate re-program to the 80°C setting and repeat until the appropriate temperature is found.

6.11 Ten Clicks – Configuration Reset (to initial shipping defaults)

This Menu option allows a reset of all options to their initial shipping defaults (Sec 4.2).

Initially the LED will be dim to indicate that a Configuration Reset will ***not*** occur (i.e. if you don't click to toggle this option). A click will brighten the LED to indicate that a Configuration Reset ***will*** occur. Each click will toggle from active to inactive. When you are satisfied with the choice, press to save the setting. The LED will flash a number of times to indicate the version number and then go dim to indicate that the selection has been made, and that the Menu mode has been reentered.

6.12 Menu Selection Complete

Once the above Menu procedure is complete and the light turns off the new Menu selection is immediately active. The circuit is ready to be used.