

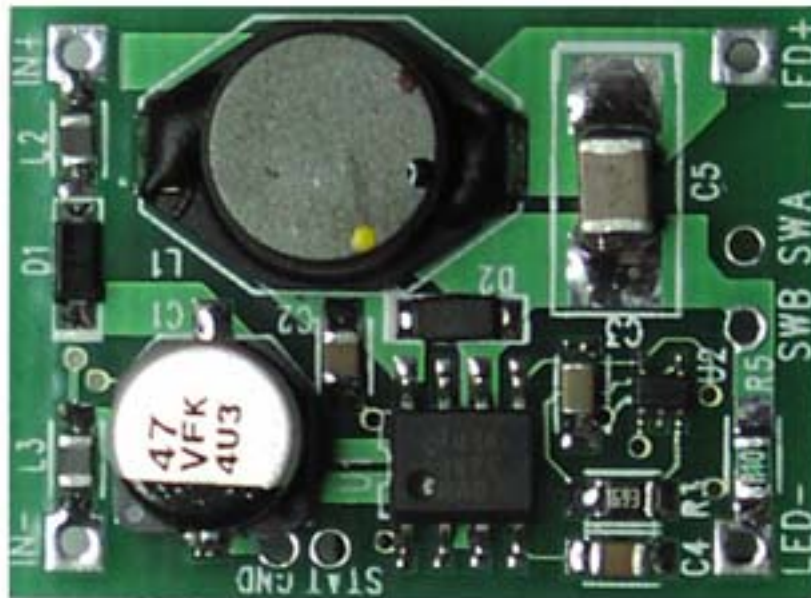
Operating Manual for nFlex UIF (V1.01)

1 Introduction

The heart of the nFlex board is a Microcontroller (uC) that contains the firmware to implement the following features:

- High efficiency Buck mode (step down) switching regulator (maximum drive current set in firmware).
- Single switch to select from various brightness levels, turn the unit on/off and to select the operating mode.
- Non-volatile (EEPROM) storage of operating mode, last selected brightness level and maximum drive level (350mA, 500mA, 750mA or 1000mA).

1.1 Wiring the nFlex



The picture shows the connections to the nFlex. The user needs to provide DC power to the nFlex (e.g. battery, DC wallwart, vehicle/boat/RV 12V).

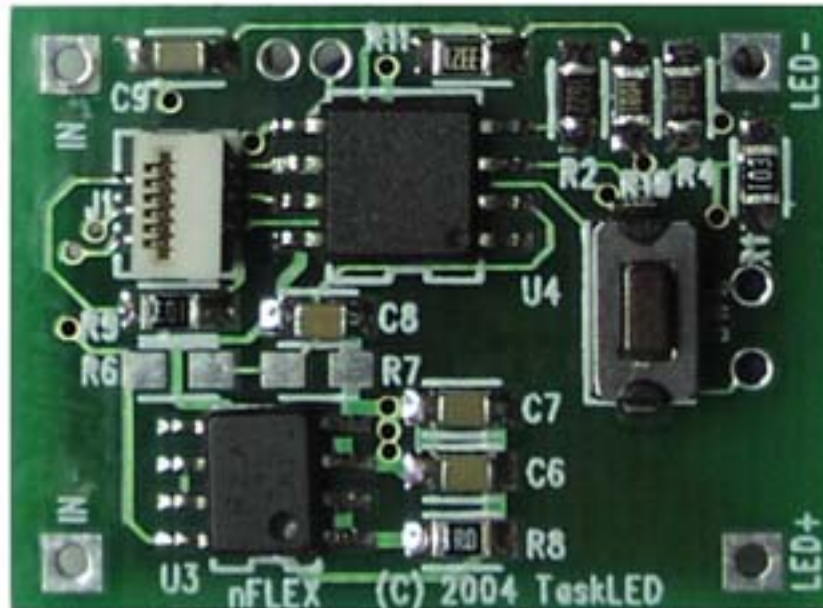
The nFlex is reverse polarity protected by a schottky diode in series with the +IN (D1 on the PCB). Ferrite beads in both the +IN and -IN help attenuate switching noise from feeding back into the input wiring that may interfere with radio communication equipment in a boat.

nFlex has a switch soldered on the board, but an additional switch may be connected via leads soldered to the holes SWA and SWB. The switch needs to be of 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-.

Below is the view of the other side of the nFlex board. The switch is in the middle right side. The small white connector is the uController programming header.



The nFlex is shipped configured for nominal 350mA drive. The user may reconfigure the nFlex drive level as described later in this document.

The following table shows the supported configurations of the nFlex.

Driver Configuration	Input voltage for regulation (min)*	Input voltage Operating (min)**	Input voltage (max)
1 1W Luxeon	$V_f+0.7V$	4V	24V
1 to 4 1W Luxeons (in series)	$\Sigma V_{fn}+0.7V$	4V	24V
1 Luxeon III	$V_f+1.1V$	4V	24V
1 to 4 Luxeon III (in series)	$\Sigma V_{fn}+1.1V$	4V	24V
1 to 2 5W Luxeon	$\Sigma V_{fn}+1.1V$	4V	24V

* Nominal Minimum input voltage to ensure current regulation is maintained (350mA drive to 1W Luxeons, 1000mA drive to 3W or 5W Luxeons). Below this voltage the nFlex may go into direct drive and the brightness will drop. If lower light levels are selected, the nFlex may be able to keep the Luxeon in current regulation due to lower V_f requirements at lower current. These dropout voltages assume that the input protection diode D1 and the ferrite beads L2 and L3 are shorted out.

V_f is the forward voltage of the Luxeon at the driven current.

ΣV_{fn} is the sum of the forward voltage of all the series connected Luxeons.

** Minimum operating voltage for nFlex.

1.2 Turning the nFlex ON the first time

Do not apply power to the nFlex unless the Luxeon(s) is/are connected. This is to protect the output capacitor and to protect the Luxeon from voltage spikes if it is then connected to the nFlex.

The nFlex is shipped with the lowest drive level (350mA) as the default and with auto-sleep mode turned off. As soon as power is first applied the nFlex will drive the Luxeon(s) at the nightlight level.

2 Operating Instructions

This section describes how to use the button to access the different features of the nFlex. A quick summary can be found in the following table.

0 – ½ second	½ - 1 ½ seconds	1 ½ - 5 seconds	5 – 10 seconds	>10 seconds
Normal on	On (nightlight)	On (Full bright)	On (auto-sleep on)	On (auto-sleep off)

2.1 Turning the nFlex ON

Pressing the button for less than ½ second will turn on the nFlex. The Luxeon(s) will not be illuminated until the button is released. This is a feature that enables the user to know if an alternate brightness level or mode change is occurring.

When the nFlex is turned on, by either applying power or pressing the button when in sleep mode, the previous brightness level will be automatically selected.

2.2 Turning the nFlex OFF

Pressing the button for less than ½ second will turn off the nFlex. The nFlex actually enters sleep mode (draws about 0.2mA). The uC disables the switching regulator control loop, the Luxeon(s) go off and the uC enters a low power sleep mode where it waits for a button press to wake it up again.

Removing input power will of course also turn the nFlex off.

2.3 Turning the nFlex ON to an alternate brightness level

Pressing the button for longer than ½ a second but less than 1½ seconds will select the nightlight illumination level. To aid the user in knowing this level is being selected, the Luxeon will illuminate at the nightlight level after ½ a second. This level is stored in the EEPROM as the current illumination level.

Pressing the button for longer than 1½ seconds but less than 5 seconds will select the full brightness illumination level. To aid the user in knowing this level is being selected, the Luxeon will switch to full brightness level after 1½ seconds. This level is stored in the EEPROM as the current illumination level.

2.4 Turning the nFlex ON and changing auto-sleep mode

Pressing the button for longer than 5 seconds but less than 10 seconds will select auto-sleep mode. To aid the user in knowing this mode is being selected, the Luxeon will illuminate at the nightlight level after 5 seconds. The nightlight illumination level along with the auto-sleep mode will be stored in the EEPROM.

Pressing the button for longer than 10 seconds will deselect auto-sleep mode. To aid the user in knowing this level is being selected, the Luxeon will switch to full brightness level after 10 seconds. The full brightness level along with the non auto-sleep mode will be stored in the EEPROM.

Auto-sleep is a feature that allows the nFlex to automatically enter sleep mode if no button press occurs within a fixed time period. The following is a description of auto-sleep in action.

- Turn unit on and set to any desired brightness level.
- 45 minutes after the last button press, one brightness level is automatically decreased every minute until nightlight level is reached
- The Luxeon remains at nightlight level until a total of 45 + 120 minutes elapses at which point the nFlex turns off and enters sleep mode (drawing 0.2mA).

If the button press occurs within 45 minutes, the auto-sleep timer is reset and the countdown starts again. If the button is pressed for longer than ½ second during the 120 minute countdown phase the brightness

level will increase (until the button is released) and the auto-sleep timer is reset and the countdown starts again. Once the unit turns off if the user turns it back on it will return to the original brightness level that it was last set to prior to beginning the auto-sleep dimming sequence.

Note: The timer that measures the elapsed time is not highly accurate. The times can easily vary 10% between nFlex boards and over the operating temperature range.

2.5 Turning the nFlex ON (examples)

Example 1: enable auto-sleep mode.

Press the button for longer than 5 seconds. The Luxeon will be off for the first $\frac{1}{2}$ second, then it will light up at nightlight level, and after $2\frac{1}{2}$ seconds will light up at full brightness and after 5 seconds will go back to nightlight level. Release the button and auto-sleep mode is now active. Auto-sleep will remain active until it is specifically reset.

Example 2: light up at nightlight level

Press the button for longer than $\frac{1}{2}$ a second. The Luxeon will be off for the first $\frac{1}{2}$ second, and then it will light up at nightlight level. Release the button and nightlight level will now be the current illumination level.

Example 3: disable auto-sleep mode.

Press the button for longer than 10 seconds. The Luxeon will be off for the first $\frac{1}{2}$ second, then it will light up at nightlight level, and after $2\frac{1}{2}$ seconds will light up at full brightness and after 5 seconds will go back to nightlight level and after 10 seconds will light up at full brightness again. Release the button and auto-sleep mode is now disabled.

2.6 Changing brightness levels

There are 7 equally spaced brightness levels (human eye model) in addition to the nightlight level. With the nFlex already switched on, the user can scroll through the brightness levels by pressing the button for longer than $\frac{1}{2}$ a second. The brightness will either increase or decrease one level every $\frac{1}{3}$ of a second. The nFlex will toggle from the bright or dim direction each time the button is released.

If the unit is turned on and the unit starts in nightlight mode, then the direction is initially set to increasing. If the unit is turned on and the unit starts in full bright mode, then the direction is initially set to decreasing. If the unit is turned on at any in between level then the direction is initially set to decreasing.

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.

2.7 Reconfiguring nFlex to 350mA, 500mA, 750mA or 1000mA

nFlex ships configured for 350mA drive level. The user can change drive levels by using the following procedure (do not skip any of the steps). A flow chart is also included below.

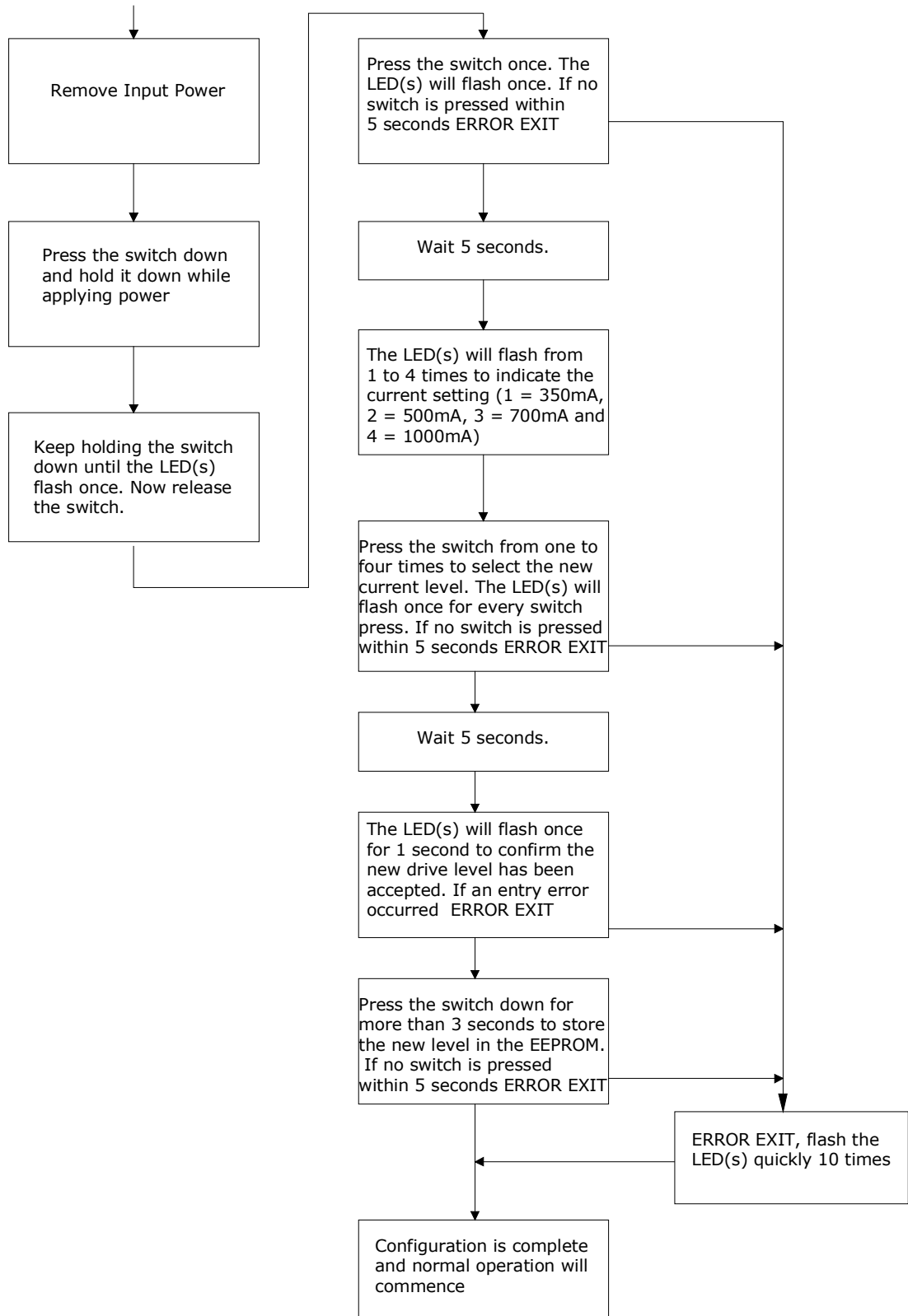
1. To reconfigure a nFlex the power must be turned off by removing input power (disconnecting the battery etc).
2. Next press the switch down and re-apply power, do not release the switch. The LED(s) will be off during this time.
3. The LED(s) will flash once to confirm configuration mode has been entered. Now, release the switch and press it once. The LED(s) will flash once to confirm you pressed the switch once. If

you don't press the switch within 5 seconds the configuration mode will exit and you will get 10 quick flashes of the LED(s) to indicate no change occurred and normal operation will then commence.

4. Wait 5 seconds.
5. The LED(s) will flash from 1 to 4 times (1 = 350mA, 2 = 500mA, 3 = 750mA, 4 = 1000mA) to indicate what the current drive level setting is.
6. Press the switch from 1 to 4 times to choose the new drive level. The LED(s) will flash for each switch press. If you don't press the switch within 5 seconds the configuration mode will exit and you will get 10 quick flashes of the LED(s) to indicate no change occurred and normal operation will then commence.
7. Wait 5 seconds
8. The LED(s) will flash once for 1 second to confirm the new drive level has been accepted. If it flashes 10 times in quick order then you entered an invalid drive level (none or > 4).
9. To accept your new drive level, press and hold the switch for more than 3 seconds. The LED(s) will flash once to confirm the new drive level has been stored in the EEPROM. If you don't press the switch within 5 seconds the configuration mode will exit and you will get 10 quick flashes of the LED(s) to indicate no change occurred and normal operation will then commence.
10. Re-configuration is complete and normal operation will then commence.

Note 1: During the entire configuration procedure no more than 350mA will be applied to the LED – this ensures that the driver can be reconfigured without applying excess current to a 1W Luxeon.

Note 2: Once nFlex is reconfigured, the new drive level is stored in the EEPROM and the change is retained until the user performs the reconfiguration procedure again.



Revision History

V1.00 First release of nFlex firmware and documentation.

V1.00a Updated number of Luxeons that nFlex can drive.

V1.00b Updated specifications for minimum input voltage where current output drops out of regulation.