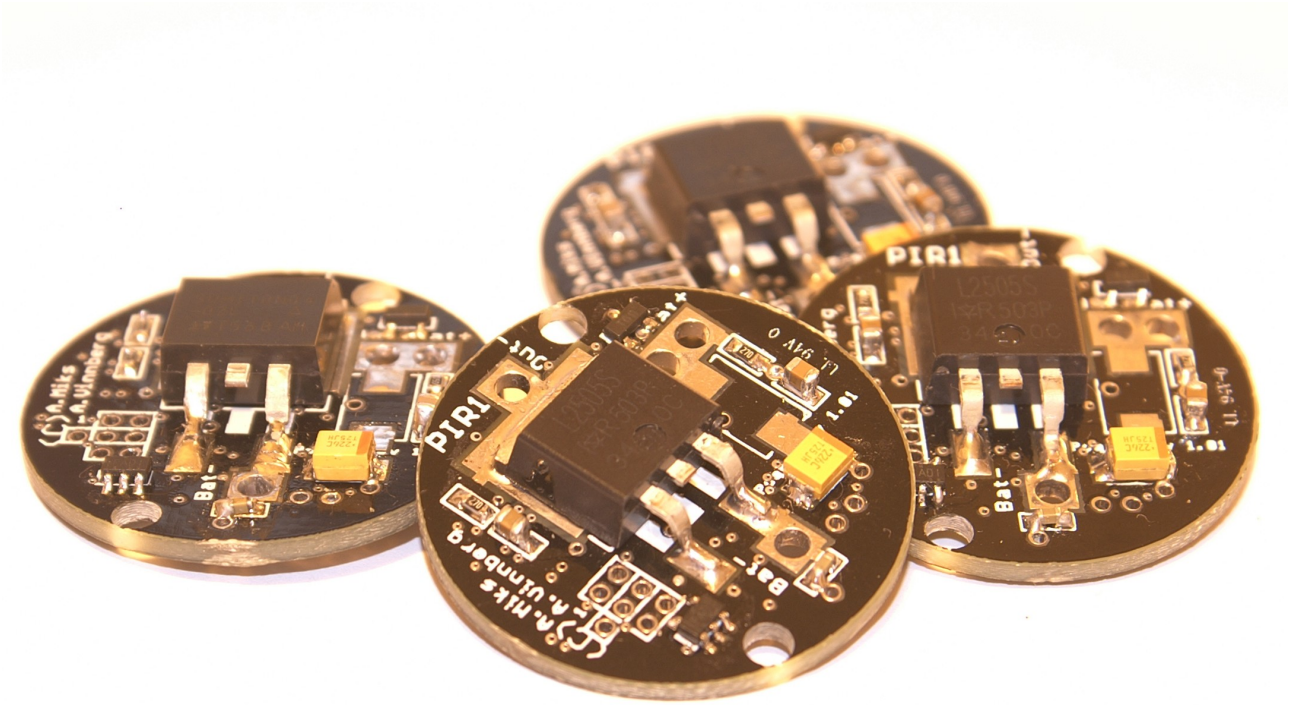
Programmable Incandescent Regulator 1
PIR 1



greenengineering.se

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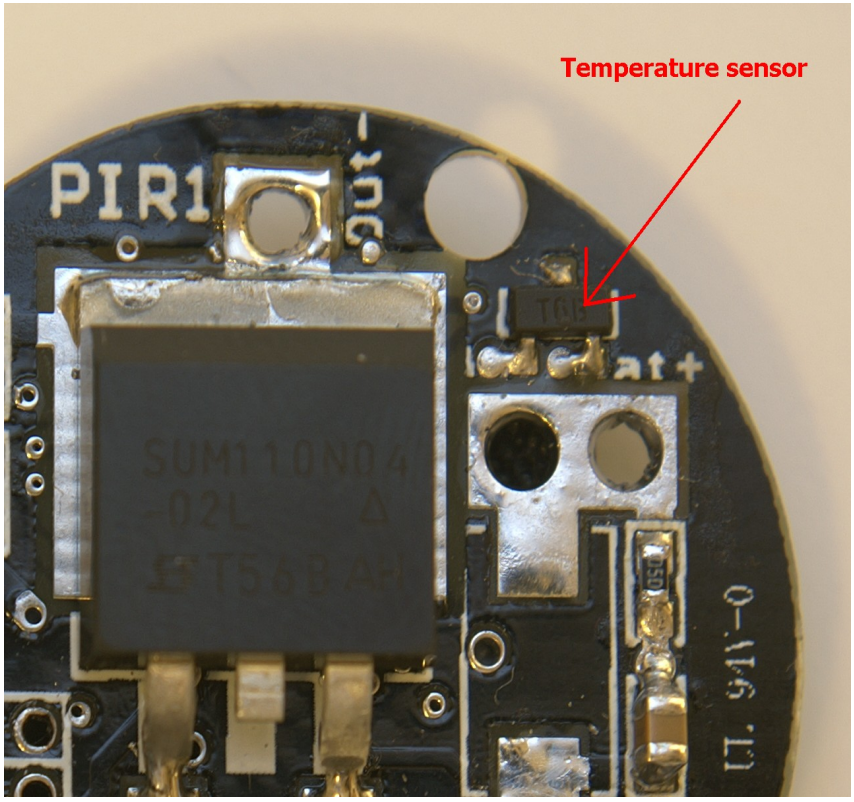
Important notices

If your regulator is running firmware 1.00, it has a logic error which causes it to stop functioning if you set the shutdown temperature below your ambient temperature. All regulators shipped before 2006-03-24 have this error. There are several workarounds to this problem if you accidentally set the shutdown temperature too low. After you have done any of the workarounds, you can set the shutdown temperature to a higher setting again.

1. Desolder the temperature sensor. This is the most difficult solution but the quickest. To desolder the sensor, use a soldering iron with a small tip and desolder the temperature sensor, located on the transistor side (not the LED side), right above the Bulb/Bat+ pad. After doing this, the regulator should start and you will be able to reset the shutdown temperature. If you are still experiencing the same problem, try touching the pads where the temperature sensor used to be. Small charges on the wires can cause the regulator to read a temperature although no sensor is present.
2. Put the regulator (and flashlight) in the freezer. You can't set shutdown temperatures blow 0 degrees Celsius so your freezer should do it. Hurry up resetting the shutdown temperature before the regulator gets warm again after you pull it out from the freezer.
3. Update the firmware by either getting the USB-programming kit and download the latest firmware or send it back to us and we will do it for you.



Picture 1. The temperature sensor

Known bugs and limitations

Pressing the switch very fast to make the regulator turn on and off in quick order may cause it to regulate to the wrong voltage, instaflash your bulb or hang the regulator. This is due to the nature of combining low standby consumption by hardware starting the regulator and debouching the button in software. We are currently working to find a solution to this. This is quite unlikely to happen but, if you really want it to hang, you probably can.

Setting a low drive voltage followed by an extreme overdrive voltage may cause your bulb to instaflash when you change from low mode to extreme high mode. The solution to this is to use levels that progressively increase the voltages or reflashing your regulator to firmware 1.01 or later.

Introduction

The PIR 1 was designed during the winter 2005/2006 in order to bring incandescent hotwires to a new level. New battery technology like lithium-ion shows great promise when it comes to energy density and power but does pose problems when you want to match the battery voltage with your light bulb voltage. Furthermore, incandescent overdriving poses problems as higher levels of overdrive increase the chance of an instaflash and eliminates all possibility for extreme overdrive unless some kind of voltage ramping is used. The PIR 1 solves this problem by allowing the user to set any voltage that is lower than the battery voltage and ramp the voltage during the startup in order to eliminate the risk of instaflash. All this is done with 95% or higher efficiency, leaving more electrons in your battery for you to turn into photons.

Picture 2. Fun with regulation

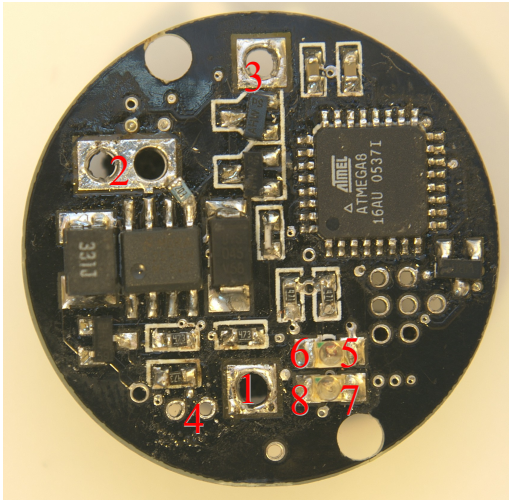
Installation

The PIR 1 was primarily designed for installation in a Kiu-socket, but its small size should allow the user to install it in many other D-sized flashlights available on the market and also user built ones.

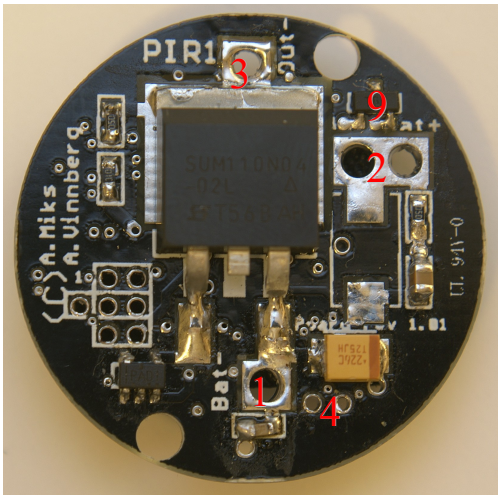
This part will only cover the installation in general. Complete step-by-step instructions for various flashlights are yet to be announced.

To begin with, it is important for the user to know that the PIR 1 does not feature any protection against reverse polarity or over voltage. Furthermore, modern production methods allow components to be manufactured with very small variations resulting in a maximum voltage rating of 30 V meaning that 30.1 V will most likely break it. This is also known as an *absolute maximum rating*. Due to this, the user must take precaution that the battery voltage does at no time exceed the specified voltage for the regulator. Therefore, keep in mind that a fully charged NiMH battery can reach up to 1.5 V /cell and a Li-ion battery can reach 4.3 V / cell when you calculate your battery voltage.

When you have double-checked and measured that your battery voltage will at no time exceed the specified voltage (either 30.0 V or 45.0 V), you can proceed and connect your battery, switch and light bulb as described in the pictures.



Picture 3. Front side



Picture 4. Back side

1. Negative pole of battery. Marked as "Bat-" on the PCB.
2. Positive pole of battery AND positive pole of light bulb. Marked as "Bulb/Bat+" on the PCB but the text is somewhat covered by the solder mask. The two holes are connected so it does not matter which one you choose as Bulb+ and Bat+.
3. Negative pole of bulb. Marked as "Out-" on the PCB.
4. Switch. Please observe, there are two holes for the switch. Not marked on the PCB.
5. Red LED, positive pole.
6. Red LED, negative pole.
7. Green/yellow LED, positive pole.
8. Green/yellow LED, negative pole.
9. Temperature sensor.

Setup

When you have connected the PIR 1 as described in the installation section, you are ready to setup your PIR 1.

It is advised not to have a light bulb connected when making your settings. The PIR 1 will start with your last used output voltage before you can reach the setup menu so if you know that your lamp can handle it, you should be ok. If this is the first time you use your regulator, the default setting will be 5.0 V output. The software is written so that the bulb will not operate while in the setup menu but it has not been tested according to the Mathias-metoden[1] so if your battery can provide more voltage than your bulb can handle, it is suggested that you do the setting without a bulb.

In order to enter the setup menu, simply press and hold the switch for seven seconds. The red LED will turn on and stay turned on until you release it.

After you release it, both LEDs will be turned off for about one second before the red LED starts to blink. The number of blinks tell you what menu you can choose to enter. By pressing the switch during, or shortly after a blinking period, you enter the menu.

The sequence goes like this. Press and wait, red LED on, release, red LED off, short pause, one blink, short pause, one blink, short pause, one blink and so on unless you press the switch during the sequence. You have to count the number of blinks by the red LED after you have released the switch.

The sum of blinks is translated into the following menus:

One blink = Set voltage 1

Two blinks = Set voltage 2

Three blinks = Set voltage 3

Four blinks = Set softstart time

Five blinks = Set cutoff voltage

Six blinks = Set warning voltage

Seven blinks = Set shutdown temperature

Eight blinks = Enter calibration menu

Nine blinks = Restore to kitchen[2] default

The first seven menus enter a mode where you set two numbers by counting the number of blinks by the red LED and pushing the switch when you want to stop. After the first number is set, there is a two second delay before the second counting sequence starts. Both counting sequences starts at 0 so one blink equals 0, two blinks equals 1, three blinks equals 2 and so on. Read the explanation of the menu to find out what the numbers mean.

Explanation of the menus:

- Set voltage 1, 2 and 3 sets the drive voltage for the bulb in the three different modes you can choose between while using the regulator. If you set any of them to 0.0, they will be ignored when you cycle between the modes.

1 A test made by Mathias Båge, the only hacker who can type in bolero-time. Originally used to test computer programs for bugs. By hammering on all keys on the keyboard for a good solid 20 minutes you can find if the program contains any bugs. If it still runs after the test, it is rock solid without any bugs.

2 Kitchen default is normally called factory default, but the PIR 1 is not built in any factory.

The first sequence sets the integer part of the voltage, ranging from 0 volt and onwards. The second sequence sets the tenth part of the voltage, ranging from .0 to .9 volt.

- Set softstart time sets the time during the startup where the voltage is ramped to softly start the lamp, thus limiting the current and avoiding instaflashes.

  The first sequence sets the hundreds of milliseconds, ranging from 0 ms and onwards. The second sequence sets the tens of milliseconds, ranging from 0 ms to 90 ms.

- Set cutoff voltage sets the battery voltage where the regulator will shut down. If you don't want to drain your batteries to the extent where you harm them, you should set this voltage to 0.9 V / cell if you are using NiMH or NiCd batteries and 2.75 V / cell if you are using Li-ion batteries. The regulator will allow you to run below this voltage for two seconds after the cutoff voltage has been reached and if you press and hold the switch while starting, this value is ignored.

  The first sequence sets the integer part of the voltage, ranging from 0 volt and onwards. The second sequence sets the tenth part of the voltage, ranging from .0 to .9 volt.

- Set warning voltage sets the battery voltage where the light bulb as well as the red LED will blink three times in order to indicate that your batteries have reached this voltage. For example, if you want a three minute warning before your cutoff voltage kicks in, you can simply set this voltage slightly higher than the cutoff voltage.

  The first sequence sets the integer part of the voltage, ranging from 0 volt and onwards. The second sequence sets the tenth part of the voltage, ranging from .0 to .9 volt.

- Set shutdown temperature sets the temperature where the regulator will turn off due to too high temperature. This is used to protect the regulator against overheating. It is not recommended to set this level over 80ºC.

  The first sequence sets the tenth part of the temperature, ranging from 0 ºC and onwards. The second sequence sets the tenth part of the voltage, ranging from .0 to .9 ºC.

- Enter calibration menu enters a sub-menu where you can re-calibrate your regulator. This menu has four sub-menus.

  One blink enters the calibrate drive - positive

  Two blinks enters the calibrate drive - negative

  Three blinks enters the calibrate cutoff - positive

  Four blinks enters the calibrate cutoff - negative

  All menus have two blinking sequences, the first for setting the integer part of the calibration value in percent. The second sets the tenth part value of the calibration. Negative means that the calibrated value is less than the original. If you first set a positive calibration value and then a negative, only the negative (last) value will be used.

  After you have done any setting (both blinking sequences), the regulator will shut down.

- Restore to kitchen default enters a sub-menu where five blinks means restore to kitchen default and shut down. All other options make no changes and shuts down your regulator. This is a safety feature so that you don't accidentally restore it to kitchen default by just entering the wrong menu.

Calibration

In case your regulator does not output the correct voltage, you can recalibrate it in several ways. Here are some examples of how to calibrate the drive voltage:

1. [default] Your regulator is calibrated enough when you receive it to fit your needs.

2. Quick and dirty method.
   If your regulator outputs to low voltage, set it for a higher value until it's bright enough for you. The opposite works if you think it's too bright. If you are planning to set and forget, this is the fastest method.

3. DC-only DMM method. **DO IT WITHOUT A BULB**
   Set the regulator for the voltage you are planning to use.
   Measure the output voltage and battery voltage with the DC-setting on your DMM.
   Calculate the real output voltage you are getting with the following formula:
   $U_{RMS} = \sqrt{(U_{bat} * U_{bulb})}$
   In-/decrease the calibration factor until you receive an the same output voltage as the one you have set.

4. DC and duty-cycle DMM method. **DO IT WITHOUT A BULB**
   Set the regulator for the voltage you are planning to use.
   Measure the output voltage from the regulator with the DC-setting on your DMM. Measure the duty-cycle from the regulator with your DMM.
   Calculate the real output voltage you are getting with the following formula:
   $U_{RMS} = U_{bat} * \sqrt{(duty)}$,
   where duty is a value between 0 and 1. Please observe that some DMMs shows for example 76% duty-cycle as 24%. If you are getting fantastically high or low values that you can't believe, try using (1-duty) = newduty or change DMM.
   In-/decrease the calibration factor until you receive an the same output voltage as the one you have set.

5. TRMS AC+DC DMM method. **DO IT WITHOUT A BULB**
   Set the regulator for the voltage you are planning to use.
   Measure the output voltage and in-/decrease the calibration factor until you receive an the same output voltage as the one you have set.

Operating

Operating the PIR 1 is simple. See the list below to find out what you can do with it.

- In order to start the regulator, press and release the switch. Your regulator will softstart as fast as you have set it to do in the setup menu to the last output setting you used.
- To turn off the regulator, press and release the switch. The regulator will turn off.
- In order to change drive voltage, press and hold the switch for three seconds. The regulator will cycle between voltage 1, voltage 2, voltage 3, voltage 1, voltage 2 and so on, depending on which setting you started at. If any voltage is set to 0.0 V, it will be ignored and the regulator will jump to the next setting.

Troubleshooting

Q: My regulator shuts down a short while after I turn it on. What's wrong?

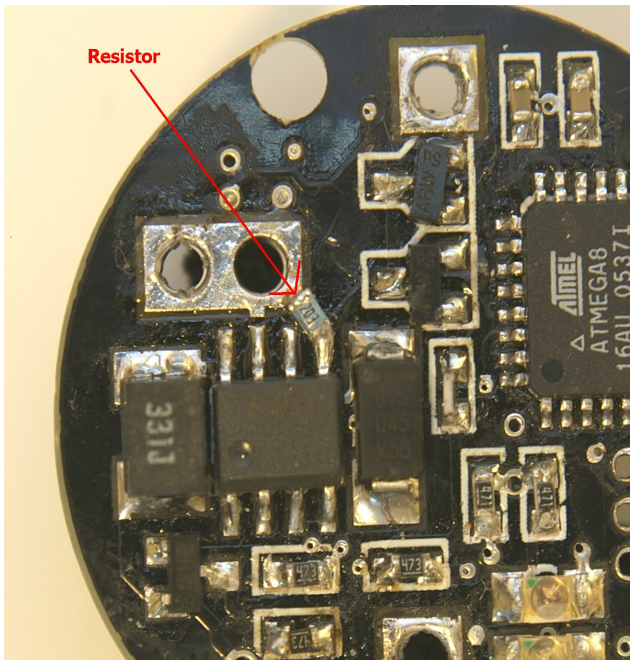
A: You have triggered the set cutoff voltage of your regulator. Try decreasing the cutoff voltage if your batteries allow it, or charge your batteries.

Q: My regulator shuts down at 10.5 V although I have set it for 10.0 V. What's wrong?

A: Try setting it for 10.1 or 9.9 V. The roundoff error in the float-conversion can be higher for certain numbers. If that doesn't help, try calibrating the cutoff voltage.

Q: My regulator won't shut down. What's wrong?

A: Check whether you have accidentally desoldered the little blue 20 kohm resistor between the Bat/Bulb+ pad and the black IC when you soldered your cables to it. If you did, your regulator can't shut down. Resolder it, get a new resistor for it if you lost it or send it back to us for fixing.



Picture 5. The post-production mounted pull-up resistor