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**M2011B**

# PIR Light Controller for DC/AC Applications

## General Description

The M2011B integrated circuit combines all required functions for a single chip Passive Infra Red (PIR) light controller.

It is designed for load switching with a transistor or a relay in 3 wire AC and DC systems.

A conventional PIR sensor connects directly to the PIR input. The pull-down resistor and DC decoupling circuitry are integrated on chip. The PIR signal is converted to a 15 bit digital value.

External potentiometers or resistors are used to set the operating parameters for sensitivity, on-time, brightness, fade, daylight sensor and environment temperature correction. The corresponding voltage levels are converted to digital values with a 4 bit resolution

All signal processing is performed digitally.

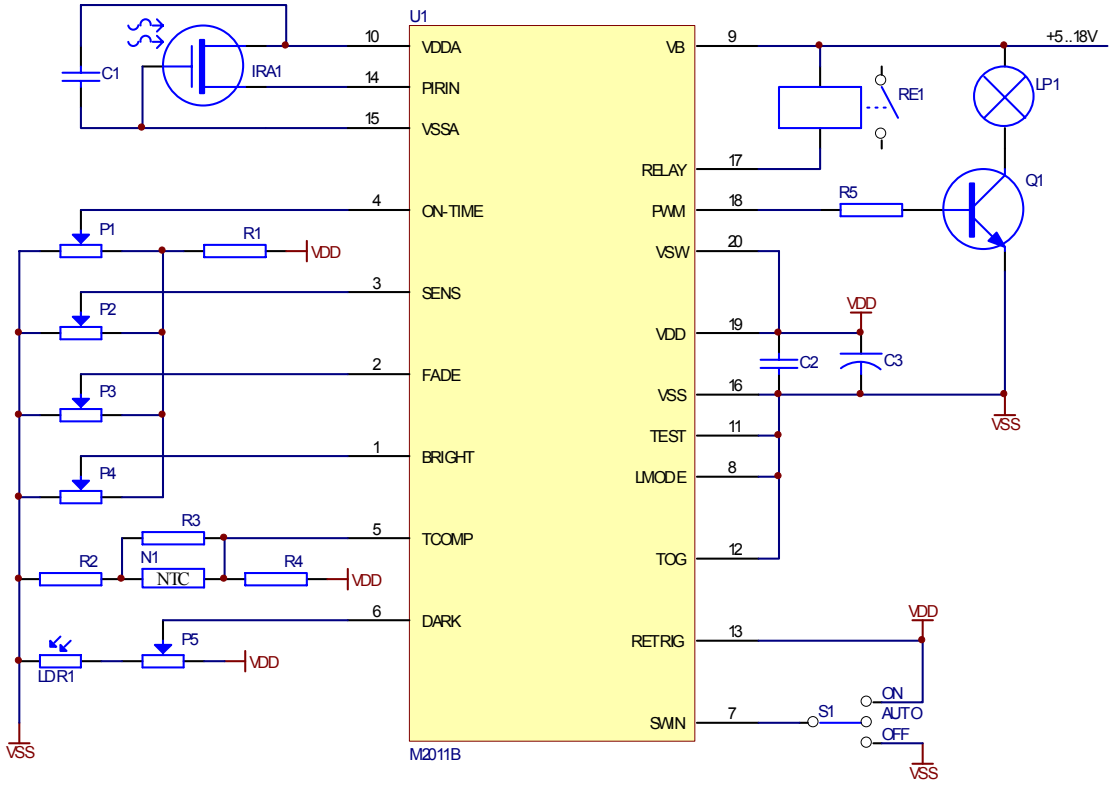
## Applications

- Battery operated lights
- Solar powered garden lights
- Outdoor and indoor motion sensor lights
- High end lighting switches
- Automatic bedroom night lights
- Energy saving

## Features

- Digital signal processing
- On chip supply regulator with wide operating voltage range
- Low power consumption
- Temperature compensation input
- Adjustable soft on/off switching (fading)
- Dimmer function
- PWM output
- Open Drain high voltage relay output
- Suitable for DC and AC applications

## Application Circuit



# Electrical Characteristics

## Absolute Maximum Ratings

| Parameter | Min | Max | Unit | Remarks |
|---|---|---|---|---|
| Voltage on pins VB, RELAY | -0.3 | 19 | V | |
| Voltage on any other pin | -0.3 | 7 | V | |
| Current into any pin | -100 | 100 | mA | One pin at a time |
| Storage temperature | -45 | 125 | °C | |

*Table 1: Electrical Characteristics (Stresses beyond those listed above may cause permanent damage to the device. Exposure to absolute maximum ratings may affect the device reliability. ESD protection: all pins will be able to withstand a discharge of a 100pF capacitor charged to 1.6kV through a 1500Ω series resistor. Test method: MIL-STD-883D method 3015).*

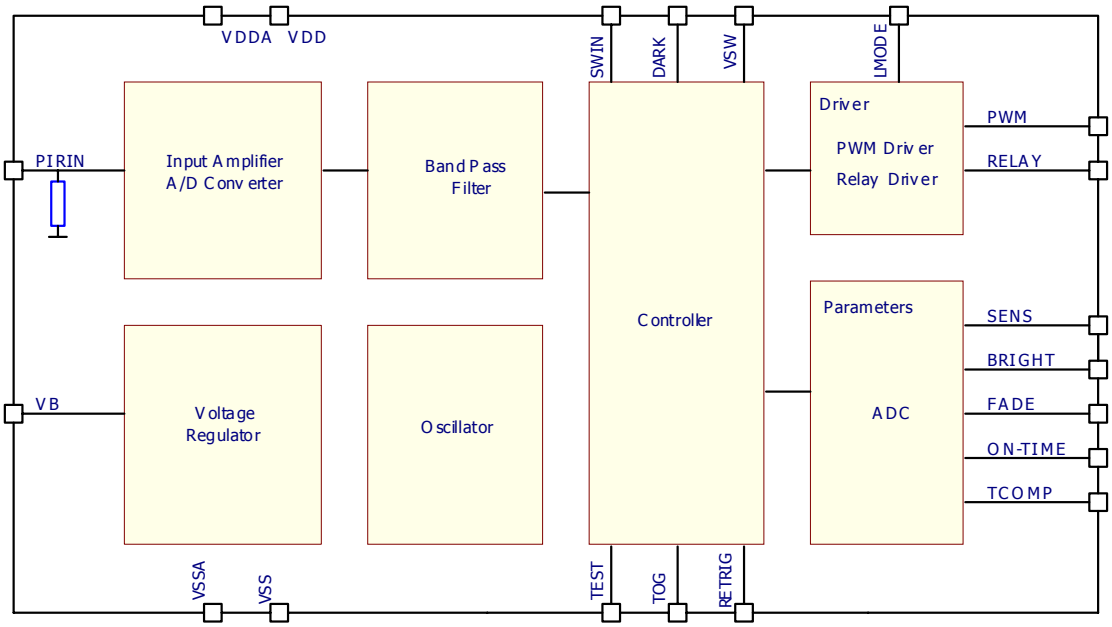
## Operating Conditions (T=25°C, VDD=5V, unless stated otherwise)

| Parameter | Min | Typ | Max | Unit | Remarks |
|---|---|---|---|---|---|
| **Temperature** | | | | | |
| Operating temperature range | -25 | | 70 | °C | |
| **Regulator** | | | | | |
| Supply voltage | 4.8 | | 18 | V | Supply voltage |
| Supply current | | | 200 | µA | $V_B$=12V (Outputs unloaded) |
| Regulator output voltage | 3.6 | | 4.4 | V | |
| **Digital Inputs, Schmitt Triggers (RETRIG, DARK, SWIN, TEST, TTEST)** | | | | | |
| Input low voltage | | | 20 | $\%V_{DD}$ | |
| Input high voltage | 80 | | | $\%V_{DD}$ | |
| Pull down current on TEST, TTEST | | 120 | | µA | input to $V_{DD}$ |
| Pull up current on RETRIG | | 120 | | µA | input to $V_{SS}$ |
| Leakage current on DARK | | | ±1 | µA | input to $V_{SS}$ or $V_{DD}$ |
| Pull up/ pull down scanning current on SWIN | | | 6 | mA | input to $V_{SS}$ or $V_{DD}$ |
| **Digital Outputs** | | | | | |
| RELAY sink capability (open drain) | 25 | | | mA | $V_{OL}$<1V |
| PWM Output low voltage | | | 10 | $\%V_{DD}$ | $I_{SOURCE}$=5mA |
| PWM Output high voltage | 90 | | | $\%V_{DD}$ | $I_{SINK}$=2mA |
| **Analog Inputs** | | | | | |
| Input leakage current (ON-TIME, SENS, FADE, BRIGHT, TCOMP) | -1 | | 1 | µA | |
| PIRIN resistance to $V_{SS}$ | | 60 | | kΩ | |
| PIRIN input AC voltage | | | 50 | mV | Peak-to-Peak |
| PIRIN input DC voltage | 0.2 | | 1.5 | V | |
| **Oscillator and Filter** | | | | | |
| LPF cutoff frequency | | 5 | | Hz | |
| HPF cutoff frequency | | 0.3 | | Hz | |
| Clock frequency | | 64 | | kHz | |

*Table 2: Operating Conditions*

**Errata:**
*The on chip oscillator is 35% faster than expected on devices with date code 0421ACIS16.*

## Detailed Description




### Voltage Regulator

The on-chip series regulator can accept a large variety of supply voltages, and generates a stable 4V supply for the internal circuitry. The $V_{DD}$ pin requires a decoupling capacitor to $V_{SS}$.

### Oscillator

The IC contains an on-chip low power oscillator. The frequency is set to 64kHz by connecting the correct resistor between CLOCK and VDD. The timing signals and cutoff frequencies of the digital filters are derived from this frequency.

### PIR Sensor Input

The PIRIN input has an internal pull-down resistor. The analog to digital converter generates a digital signal from the voltage level measured on the PIRIN pin.

### Band-Pass Filter

A 2nd order low-pass filter with a cut-off frequency of 5 Hz eliminates unwanted higher frequency components. This signal is then passed to a 2nd order high pass filter with a 0.3Hz cut-off frequency.

### Parameter Settings

5 different parameters can be set by changing the voltages on these pins between $V_{SS}$ and $V_{DD}$*7/32.

**SENS:** Sets the sensitivity threshold required to generate a trigger condition. Refer to table 3.

**BRIGHT:** Sets the maximum brightness of the light connected to the PWM output. The brightness levels are divided into 15 steps. Maximum brightness occurs at a pin voltage of 15/64*VDD.

**FADE:** Sets the time it takes to switch the light on or off (soft dimming). Refer to table 3.

**ON-TIME:** Sets the time for the light to remain on. Refer to table 3.

| Pin voltage/ $V_{DD}$ | On time (s) | Fade time (s) | SENS threshold |
|---|---|---|---|
| 7/32 | 1280 | 4.0 | 128 |
| 6/32 | 640 | 3.5 | 64 |
| 5/32 | 320 | 3.0 | 32 |
| 4/32 | 160 | 2.5 | 16 |
| 3/32 | 80 | 2.0 | 8 |
| 2/32 | 40 | 1.5 | 4 |
| 1/32 | 20 | 1.0 | 2 |
| 0/32 | 10 | 0.5 | 1 |

*Table 3: On-time and Fade-time*

**TCOMP:** Temperature compensation input pin. A temperature dependent resistor network may be connected to this pin to generate voltages between VDD*16/128 and VDD*31/128. The voltage on this pin must decrease as the temperature increases. At 37°C, the voltage should be between VDD*19/128 and VDD*20/128. Internally, a TCOMP factor is selected, based on this pin voltage. This TCOMP factor is multiplied with the sensitivity threshold. Table 4 shows the relationship between TCOMP pin voltage and the TCOMP factor used by the threshold comparator. The TCOMP input may be connected to VSS if the application does not require a temperature compensation function.

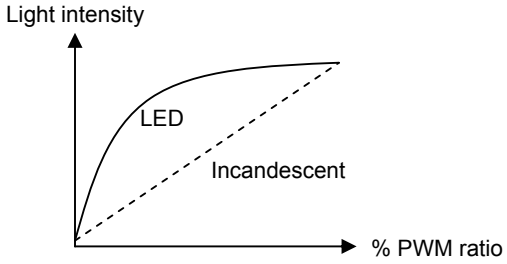
| Pin voltage/ $V_{DD}$ | TCOMP factor | Pin voltage/ $V_{DD}$ | TCOMP Factor |
|---|---|---|---|
| <16/128 | 7/8 | 24/128 | 8/8 |
| 17/128 | 6/8 | 25/128 | 9/8 |
| 18/128 | 5/8 | 26/128 | 10/8 |
| 19/128 | 4/8 | 27/128 | 11/8 |
| 20/128 | 4/8 | 28/128 | 12/8 |
| 21/128 | 5/8 | 29/128 | 13/8 |
| 22/128 | 6/8 | 30/128 | 14/8 |
| 23/128 | 7/8 | >31/128 | 15/8 |

*Table 4: Temperature compensation factor*

## PWM and RELAY output drivers

The load can be switched ON and OFF with a relay, using the RELAY open collector output.

When fading and brightness control are desired, the PWM output must be used. An external transistor is normally required to switch the load current. The light intensity versus PWM ratio is different for an LED than an incandescent light, as indicated in the figure below.




For this reason, the PWM steps are different when setting the LMODE high (for LED's) or low (for incandescent).

## VSW input

The VSW input may be used to sense a slow charging relay supply voltage before enabling the outputs of the device. The RELAY and PWM outputs becomes active when the VSW > 0.9*VDD. RELAY and PWM outputs becomes inactive when the VSW < 0.7*VDD.

## Controller: Modes of Operation

The operating modes are determined by four digital inputs. The digital inputs can be connected to $V_{DD}$, $V_{SS}$ or some can be left floating, as indicated below.

| Pin Name | Description |
|---|---|
| SWIN | Selects the ON-AUTO-OFF mode.<br>$V_{DD}$: light permanently ON<br>$V_{SS}$: light permanently OFF<br>Floating: PIR sensor mode (AUTO) |
| RETRIG | Re-trigger Mode<br>$V_{DD}$ or floating: As long as movement is detected within the on-time, the light will remain on.<br>$V_{SS}$: The light will first switch off, before it can be switched on again. |
| DARK | Typically connected to a Light Dependant Resistor (LDR) or photo transistor, to prevent the light from switching on during daylight conditions.<br>$V_{DD}$: Enable switching of the light<br>$V_{SS}$: Disable switching of the light |

*Table 5: Operational parameters*

# *Operation*

## Power-up Mode

Whenever the circuit is powered up, the light is switched on for the selected on-time duration. The DARK input is ignored on power-up, to allow the user to verify the installation during daylight conditions.

## Trigger condition

The SENS threshold (refer to table 3) is multiplied with the TCOMP factor (refer to table 4), to obtain a temperature dependent threshold. When the filtered PIR signal exceeds this threshold, a trigger condition occurs.

## Conditions for Switching the Light ON (AUTO mode)

If a trigger condition occurs and the DARK input is high, the light will be switched on. The light's brightness will increase to the selected brightness within the selected fade time.

The RELAY output is activated at the start of the fading-on cycle. The light and the relay will remain on for the duration set by the ON-TIME input.

## Conditions for Switching the Light OFF (AUTO mode)

The light is switched off softly after the selected ON-TIME has elapsed, or if the DARK input senses a low voltage. The light's brightness will reduce to zero within the selected fade time. The RELAY output is switched off at the start of the fading-off cycle.

## Device Pin Out

| Pin No. | Name | Description |
|---|---|---|
| 1 | BRIGHT | Brightness adjustment |
| 2 | FADE | Fade time adjustment |
| 3 | SENS | Sensitivity threshold adjustment |
| 4 | ON-TIME | Light on-time adjustment |
| 5 | TCOMP | Temperature compensation input |
| 6 | DARK | Dark mode input, connected to LDR/Photodiode |
| 7 | SWIN | ON-AUTO-OFF select input |
| 8 | LMODE | LED mode select |
| 9 | VB | Supply voltage input |
| 10 | VDDA | Analog supply |
| 11 | TEST | Reserved test mode, connect to VSS |
| 12 | TTEST | Reserved test mode (TOG), connect to VSS |
| 13 | RETRIG | Retrigger mode select input |
| 14 | PIRIN | PIR sensor input |
| 15 | VSSA | Analog ground |
| 16 | VSS | Digital ground |
| 17 | RELAY | Relay output pin |
| 18 | PWM | Light output (PWM) |
| 19 | VDD | Digital VDD |
| 20 | VSW | Voltage sense input |

*Table 6: Device Pin Out*

## Component Values

| Designator | Description |
|---|---|
| R1 | 33k |
| R2 | 20k |
| R3 | 22k |
| R4 | 180k |
| R5* | 1k to 50k, load dependent |
| P1,P2, P3, P4 | 47k |
| C1, C2 | 470nF |
| C3 | 10µF |
| IRA1 | LHI 878, Perkin Elmer |
| Q1* | NPN |
| N1 | NTC 47k |
| LDR1* | Light dependent resistor |
| P5* | Trim pot |

*Table 7: Component Values for Application Circuit (*Suitable component values must be determined by the manufacturer)*

## Contact Information

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## Ordering Information

M2011B-SO20-300 (Surface mount, 300 mil)

Other packages are available on request