M2000C

PIR Light Controller for 3-Wire Applications

General Description

The M2000C integrated circuit combines all required functions for a single chip Passive Infra Red (PIR) light controller.

It is designed for load switching with a TRIAC or a relay in 3 wire 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.

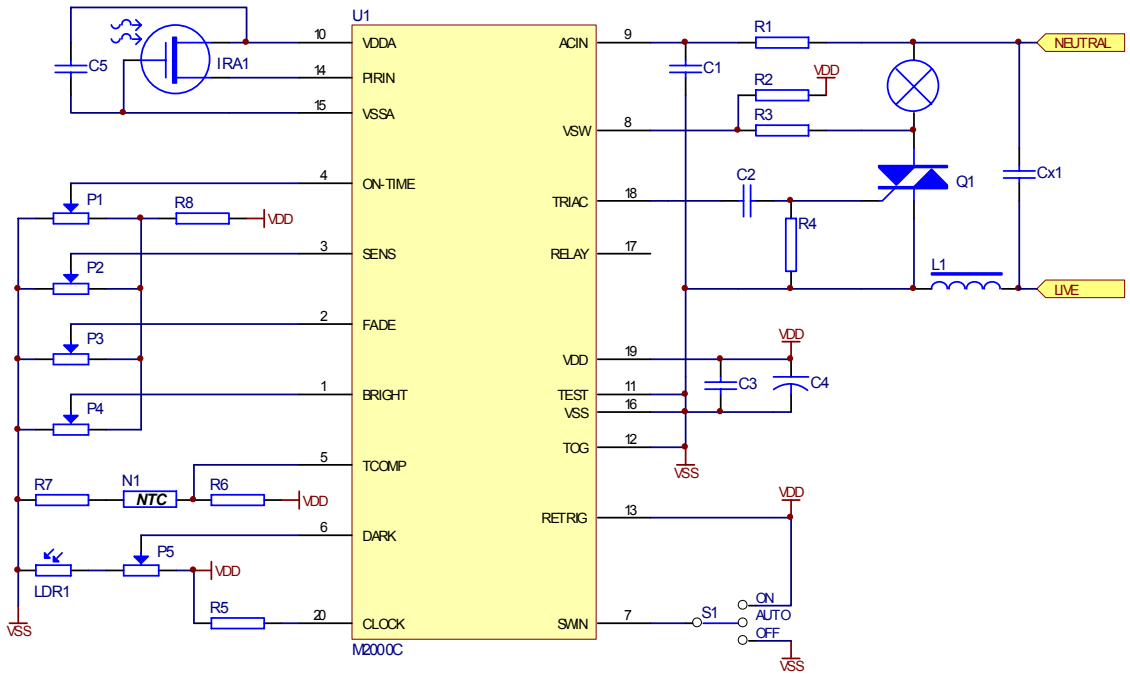
Applications

- Outdoor and indoor motion sensor lights
- High end lighting switches
- Automatic bedroom night lights
- Energy saving

Features

- Digital signal processing
- On chip rectifier and supply regulator
- Low power consumption
- Temperature compensation input
- Adjustable soft on/off switching (fading)
- Dimmer function
- Inductive load switching
- Capacitive load on/off switching
- Four quadrant TRIAC driver
- Suitable for 115V/60Hz and 230V/50Hz applications
- Low TRIAC switching noise

Application Circuit



Electrical Characteristics

Absolute Maximum Ratings

Parameter	Symbol	Min	Max	Unit	Remarks
Supply Voltage	V_{DD}	-0.3	7	V	
Current into any pin		-100	100	mA	One pin at a time
Storage Temperature	T_{st}	-45	125	°C	

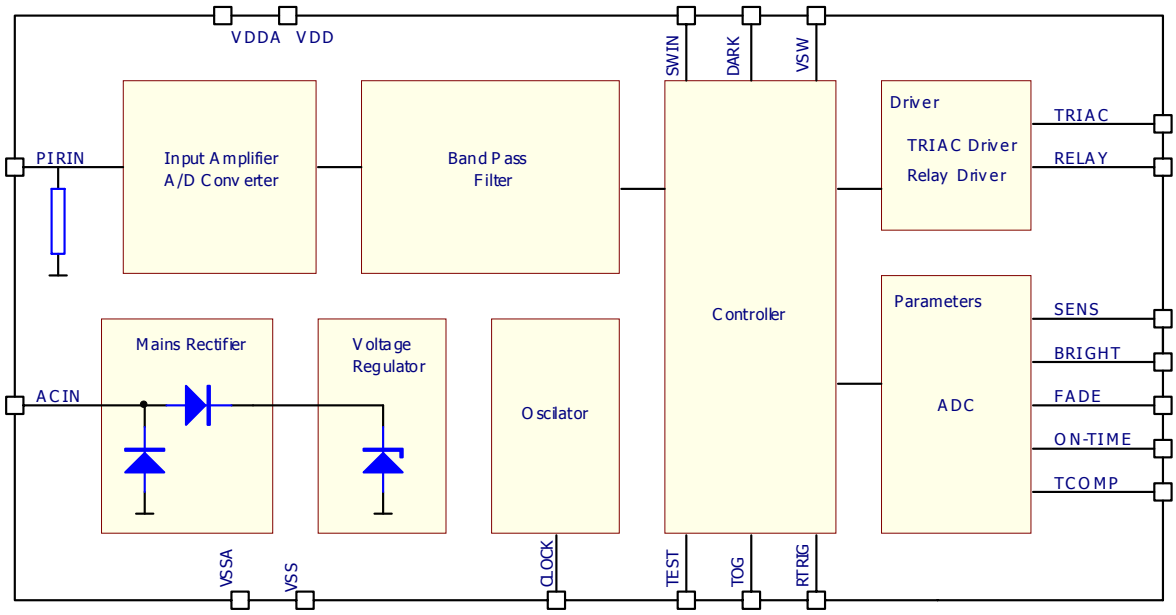
Table 1: Electrical Characteristics (Stresses beyond those listed above may cause permanent damage to the device. Exposure to absolute maximum ratings may affect the device reliability. ESD protection: all pins will be able to withstand a discharge of a 100pF capacitor charged to 1.6kV through a 1500Ω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

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

Parameter	Symbol	Min	Typ	Max	Unit	Remarks
Temperature						
Operating temperature range		-25	25	70	°C	
Rectifier / Regulator						
Supply voltage	V_{DD}	4.2	5	5.5	V	
Supply current	I_{DD}			500	µA	V_{DD}=5VOutputs unloaded
Shunt regulator current	I_{ACIN}			20	mA	V_{DD}=6V
Digital Inputs, Schmitt triggers (TEST, TOG, RETRIG, DARK, SWIN)						
Input low voltage	VIL			20	%VDD	
Input high voltage	VIH	80			%VDD	
Pull down current on TEST,TOG			140		µA	Input to V_{DD}
Pull up current on RETRIG			140		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}
VSW Digital Input (window comparator)						
Input low voltage	V_{SWL}			1	V	
Input high voltage	V_{SWH}	V_{DD}-1			V	
Digital Outputs (RELAY, TRIAC)						
Output low voltage	V_{OL}			10	$\%V_{DD}$	I_{SOURCE}=5mA
Output high voltage	V_{OH}	90			$\%V_{DD}$	I_{SINK}=2mA
Analog Inputs						
Input voltage range		0		V_{DD}	V	
Input leakage current (ON-TIME, SENS, FADE, BRIGHT, TCOMP)		-1		1	µA	
PIRIN input resistance to V_{SS}			60		kΩ	
PIRIN input AC voltage				5	mV	Peak-to-Peak
Oscillator and Filter						
LPF cutoff frequency			7		Hz	
HPF cutoff frequency			0.5		Hz	
Internal clock frequency			25.6		kHz	R5 as per table 7

Table 2: Operating Conditions

Detailed Description



Mains Rectifier

The M2000C contains an on chip half wave rectifier. The ACIN input is connected to the mains voltage through an external voltage dropper resistor.

Voltage Regulator

A shunt regulator between V_{DD} and V_{SS} limits the supply voltage to 5V. An external capacitor has to be connected between V_{DD} and V_{SS}.

Oscillator

The IC contains an on chip oscillator. The frequency is set to about 52 kHz for 50Hz systems and 64kHz for 60Hz systems by selecting the correct resistor between CLOCK and V_{DD}. All timing signals and cutoff frequencies of the digital filters are derived from this frequency.

Input amplifier and A/D Converter

The PIRIN input has an internal pull-down resistor and DC decoupling circuitry. The signal voltage on the PIR input is converted to a 14 bit digital value.

Band-Pass Filter

A 2^{nd} order digital Butterworth band-pass filter eliminates unwanted frequency components above and below the band of interest (0.4Hz .. 7Hz).

Threshold Comparator

The output signal from the band pass filter is digitally rectified and its peak value compared against a threshold value calculated from the voltages on the SENS and TCOMP inputs. Whenever the PIR signal exceeds the threshold, the load is switched on.

Parameter Settings

The M2000C provides for five inputs, which are used to define the operational parameters. The voltage applied on these inputs are converted to 4 (3) bit digital values. A value of 16 (8) corresponds to a voltage of >VDD/4, a value of 0 to VDD/4/16 (8).

SENS: Sets the sensitivity threshold required to generate a trigger condition. Eight different threshold values are possible. Refer to table 3. The threshold value internally recalculated with the temperature compensation factor.

BRIGHT: Sets the maximum brightness of the light. The brightness levels are divided into 15 equal steps. One steps corresponds to 90*(1- 1/16) degrees phase angle.

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

ON-TIME: Sets the time the light remains on. Refer to table 3.

Pin voltage/ V_{DD}	On time (s)	Fade time (s)	SENS threshold
7/32	1280	3.7	128
6/32	640	3.3	64
5/32	320	2.8	32
4/32	160	2.1	16
3/32	80	1.2	8
2/32	40	0.9	4
1/32	20	0.3	2
0/32	10	0	1

Table 3: On-time and Fade-time

TCOMP: A temperature dependent resistor network can be connected to this pin. A voltage range of VDD*16/128 to VDD*31/128 is converted to a set of threshold multiplication factors. 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. Refer to table 4.

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

Table 4: Temperature compensation factor

TRIAC and RELAY output drivers

The TRIAC output generates a square wave, synchronous with the mains voltage. To control the brightness of the light, the square wave is delayed with regards to the mains cycle zero-crossings. The rising edge of the square wave triggers the TRIAC for the positive cycle and the falling edge triggers the TRIAC for the negative cycle.

The RELAY pin is an active high output and changes state at the start of the fading cycle.

Controller: Modes of Operation

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

Pin Name	Description
SWIN	Selects the ON-AUTO-OFF mode. V_{DD}: light permanently ON V_{SS}[1]: light permanently OFF Floating: PIR sensor mode (AUTO)
TOG	V_{DD}: mains toggling enabled. V_{SS} or floating: mains toggling disabled. Also refer to 'Conditions for switching the light ON'.
RETRIG	Re-trigger Mode V_{DD} or floating: As long as movement is detected within the on-time, the light will remain on. 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. V_{DD}: Enable switching of the light V_{SS}: Disables switching of the light Do not leave this input floating

Table 5: Operational parameters

[1] The toggle mode is not cancelled by setting SWIN input to V_{SS}, although the light will be switched off

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 temperature dependent 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.

If the TOG input is high, the light can also be switched on by toggling the mains ON-OFF-ON within 3 seconds. In this mode, the PIR inputs are ignored, the DARK input will switch the light ON or OFF. This mode is disabled by disconnecting the mains for a few seconds.

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	Set maximum brightness of light
2	FADE	Set fading time of light
3	SENS	Set sensitivity threshold for switching light on
4	ON-TIME	Set light on time
5	TCOMP	Temperature compensation input
6	DARK	Dark mode input, connected to LDR/Photodiode
7	SWIN	ON-AUTO-OFF select input
8	VSW	Input voltage sensor
9	ACIN	Mains power in (rectifier)
10	V_{DDA}	Analog supply
11	TEST	Reserved test mode, connect to VSS
12	TOG	Selects Toggle Mode
13	RETRIG	Selects Re-trigger mode
14	PIRIN	PIR sensor input
15	V_{SSA}	Analog ground
16	V_{SS}	Digital ground
17	RELAY	Relay Output, push-pull
18	TRIAC	TRIAC gate signal, push-pull
19	V_{DD}	Digital supply
20	CLOCK	Set oscillator frequency

Table 6: Device Pin Out

Component Values

Designator	Description
R1	88kΩ (230V~) 1/2W 44kΩ (110V~) 1/2W
R2, R3	1MΩ
R4	10kΩ
R5	470kΩ
R6	180kΩ
R7	18kΩ
R8	33kΩ
P1, P2, P3, P4	47kΩ Trim pot
C1	10nF
C2	100nF
C4	470µF, 16V
C3,C5	470nF
IRA1	LHI 878, Perkin Elmer
Q1	BT136 TRIAC 600V, 4A
L1 CX1	Inductor 100..1500µH 100..220nF, class X (dependent on local EMC regulations)
N1	NTC 47k
LDR1*	Light Dependant Resistor
P5*	Trim pot

Table 7: Component Values for Application Circuit

Contact Information

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Ordering Information

M2000C-DIP20 (Dual-in-line plastic)
M2000C-SO20-300 (Surface mount, 300 mills)
M2000C-DIE (Unpackaged devices)

Other packages are available on request.