



INFRARED MOTION DETECTOR MANUAL

GLMDA MOTION DETECTOR KIT

GLOLAB
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Thank you for buying our GLMDA Motion Detector kit.

The goal of Glolab is to produce top quality electronic kits, products and components. All of our kits are designed by Glolab engineers and tested in our laboratory. Mechanical devices, prototypes and enclosures are fabricated in our precision machine shop.

Glolab Corporation has two locations in New York's Hudson Valley. Our electronics laboratory and kit packaging is located in Wappingers Falls and our machine shop is in Lagrangeville.

In addition to our kits, RF modules and GLMDA modules, we supply some special and hard to find parts such as our Pyroelectric Infrared Sensor and Infrared Fresnel lens for those of you who want to design and build your own projects.

Technical help is available by email from lab@glolab.com.

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Introduction_____

The GLMDA motion detector kit consists of an etched, drilled and screened printed circuit board and all board mounted parts that must be assembled by mounting the parts on the board and soldering them in place. This is a high-density PC board that requires careful assembly and soldering.

The GLMDA is designed to detect the motion of a human or animal both in daylight and at night and to provide a normally open relay output that can be used to activate many types of loads. The GLMDA also has terminals for connecting an optional photocell to prevent activation of the load during daylight.

Features_____

- **PC board with legends for easy parts placement**
 - **High density, small 1.7" X 2.4" board size**
- **All on-board components supplied with kit**
- **PIR sensor mounts on back side of board**
 - **Components do not interfere with mounting or lens**
- **Amplifier gain control**
 - **Adjusts detection range**
- **Adjustable delay between sensed motion events**
 - **Can be re-triggered or non re-triggered**
- **Adjustable time that load stays on**
 - **Can be re-triggered or non re-triggered**
- **SPST normally open relay output**
 - **Relay contacts rated 3 amps at 120 VAC or 32 VDC**
- **Powered by 6 to 14.5 VDC**
 - **Reverse polarity protected**
 - **Micropower circuits extend battery life**

GLMDA _____

Description

The GLMDA is 1.7 X 2.4 inches with circuit components on one side and a pyroelectric infrared sensor on the other side. The module should be mounted with the 2.4 inch dimension vertical for maximum sensitivity to horizontal motion. Four holes on the corners accept # 4 mounting screws. A Fresnel lens or other focusing device can be placed in front of the sensor to increase sensing distance by focusing infrared radiation onto the sensor elements.

Sensitivity

The component side of the GLMDA has a sensitivity adjustment R10 that controls amplifier gain and therefore range (detection distance). Turning the adjustment clockwise increases sensitivity and gives a greater range.

The pyroelectric infrared sensor in the GLMDA will detect a human or animal more easily at lower ambient temperatures when there is a greater difference between the human or animal body temperature and surrounding objects.

Day / Night control

An optional external resistive photo-conductive cell (not supplied) may be connected to the terminals marked C to de-activate the circuit during daylight so that a load will be activated only at night. This is useful if the GLMDA is used to turn a light ON.

Delay between sensing

A single shot circuit controls the amount of time that elapses between motion events that activate a load. This is useful for applications where continued motion might occur and rapid repeat activation of a load is not desired, for example when someone is standing outside a door in view of the sensor. Delay can be varied from 1 second to about 1.5 minutes by adjusting R14. The single shot is re-triggerable so that continued motion will extend the delay. Non re-triggering mode is selected by wiring a jumper across the terminals marked E.

Time that load remains on

Another single shot circuit controls the amount of time that a load remains turned ON after motion is detected. ON time can be varied from 1 second to about 1.5 minutes by adjusting R19. This is useful for applications such as keeping a light ON until a house is entered. The single shot is re-triggerable so that continued motion will extend the ON time. Non re-triggering mode is selected by wiring a jumper across the terminals marked W.

Power

A 6 to 14.5 volt battery will power the circuits. Power is connected to the GLMDA solder pads marked "PWR, + and –". The module circuits draw less than 150 microamperes when no motion is detected and less than 50 milliamperes when motion is detected and the relay is energized. In average use with a short on time, the GLMDA will draw only 150 microamperes most of the time. A nine volt alkaline battery should power the module for several months and possibly much longer.

The power system is reverse polarity protected so that a reversed power source will not damage the circuits. A DC wall transformer may also power the GLMDA, however most wall transformers output much higher than their rated voltage when lightly loaded so the transformer output should be measured to be sure that the 14.5 volt maximum GLMDA power supply input is not exceeded.

Capacitors in the amplifier and timing circuits require time to charge up to their normal operating voltages before the circuits will operate correctly. The circuits will not respond to motion until about one minute after power is applied.

Installation

Connect a power source to the PC board power pads marked + PWR –. Connect a load to the PC board relay terminals marked RY. **The RY terminals are not a source of power for a load; they just connect together through the relay contacts when motion is sensed.** A load must be powered by an external source that will be switched OFF and ON by the relay.

A thin plastic Fresnel lens that will extend detection range can be purchased separately, mounted in an enclosure and held in place with tape or silicone rubber. There is no known effective adhesive that will bond to the lens material without the danger of damage to its surface. Although silicone rubber will not bond to the lens, it can be applied so as to overlap the edge of the lens and form a captive mount.

If a Glolab FL65 long range Fresnel lens having a focal length of 0.65 inch is used and mounted against the inner surface of an enclosure, four 7/8 inch (22.225mm) long threaded nylon spacers Digi-Key ¹ p/n 1902GK will mount the GLMDA PC board so that the sensor is the correct distance from the lens.

Note:

1. Digi-Key Corporation, www.digikey.com, 1-800-344-4539

ABSOLUTE MAXIMUM RATINGS

PARAMETER	RATING	UNITS
Power supply voltage ^{2, 3}	15.0	Volts
Load current ⁴	3	Amperes

Notes:

2. Voltage from + to – power terminals on PC board
3. Reverse polarity protected
4. 120 VAC, 32 VDC

TYPICAL OPERATION

PARAMETER	MIN	TYPICAL	MAX	UNITS
Power supply voltage ^{5 6}	5.6	9.0	14.5	Volts
Load current ⁷	-	-	3	Amperes

Notes:

5. Voltage from + to – power terminals on PC board
6. Reverse polarity protected
7. 120 VAC or 32 VDC

Ordering information _____

PART NUMBER	DESCRIPTION
GLMDA	Motion detector kit includes PC board and all board mounted parts

Optional accessory parts _____

PART NUMBER	DESCRIPTION	SOURCE
FL65	Long distance single element Fresnel lens	GloLab
PDV-P8001	CDS photo conductive cell for day/night ⁸	Digi-Key Corp.

Note:

8. Digi-Key Corporation, www.digikey.com, 1-800-344-4539

GLMDA PARTS LIST

GLMDA PARTS DESCRIPTION	SOURCE	PART NUMBER
R1, R11 – 100K 1/8 watt 5% carbon film	Xicon	100K
R2, R3, R5, R13, R20 – 10K 1/8 watt 5% carbon film	Xicon	10K
R4, R12, R15, R16, R17, R18 – 1 MEG 1/8 watt 5% carbon film	Xicon	1M
R6, R9 – 2 MEG 1/8 watt 5% carbon film	Xicon	2M
R7, R8 – 150K 1/8 watt 5% carbon film	Xicon	150K
R10, R14, R19 – 1 MEG potentiometer	Panasonic	EVM-L4GA00B16
D1, D2, D3 – 1N914 diode	Fairchild	1N914
D4 – BAT46 Schottky diode	STM	BAT46
C1 – 100 pf 50 volt ceramic disc	Xicon	50S5-101J
C2, C3, C5 – 10 MFD 16 volt electrolytic	Xicon	MLRL16V10
C4, C6, C11, C12 - .1 MFD 50 volt metalized film	Panasonic	ECQ-V1H104JL
C7, C8, C9, C13 – 100 MFD 16 volt electrolytic	Xicon	MLRL16V100
C10 – 1 MFD 50 volt electrolytic	Xicon	MLRL50V1.0
Q1 – 2N7000 Field Effect Transistor	Fairchild	2N7000
IC1 – LP324 or equivalent micropower quad operational amplifier	National	LP324N
IC2 – CD4538 CMOS dual single shot	Fairchild	CD4538BCN
IC3 – micropower voltage regulator	Seiko	S-812C50AY-B
PIR325 pyroelectric infrared sensor	Globlab	PIR325
O RING – spacer	Polydraulic	BUNA-N size 009
RY1 – SPST NO relay, 5 volt 40 MA coil	P&B	T77S1D3-05
IC socket - 14 pin	AMP	390261-3
IC socket - 16 pin	AMP	390261-5
PC board	Globlab	GLMDPCB

Data sheets for the LP324 operational amplifier, CD4538 single shot and 2N7000 FET may be viewed and downloaded at the Fairchild Semiconductor website www.fairchildsemi.com

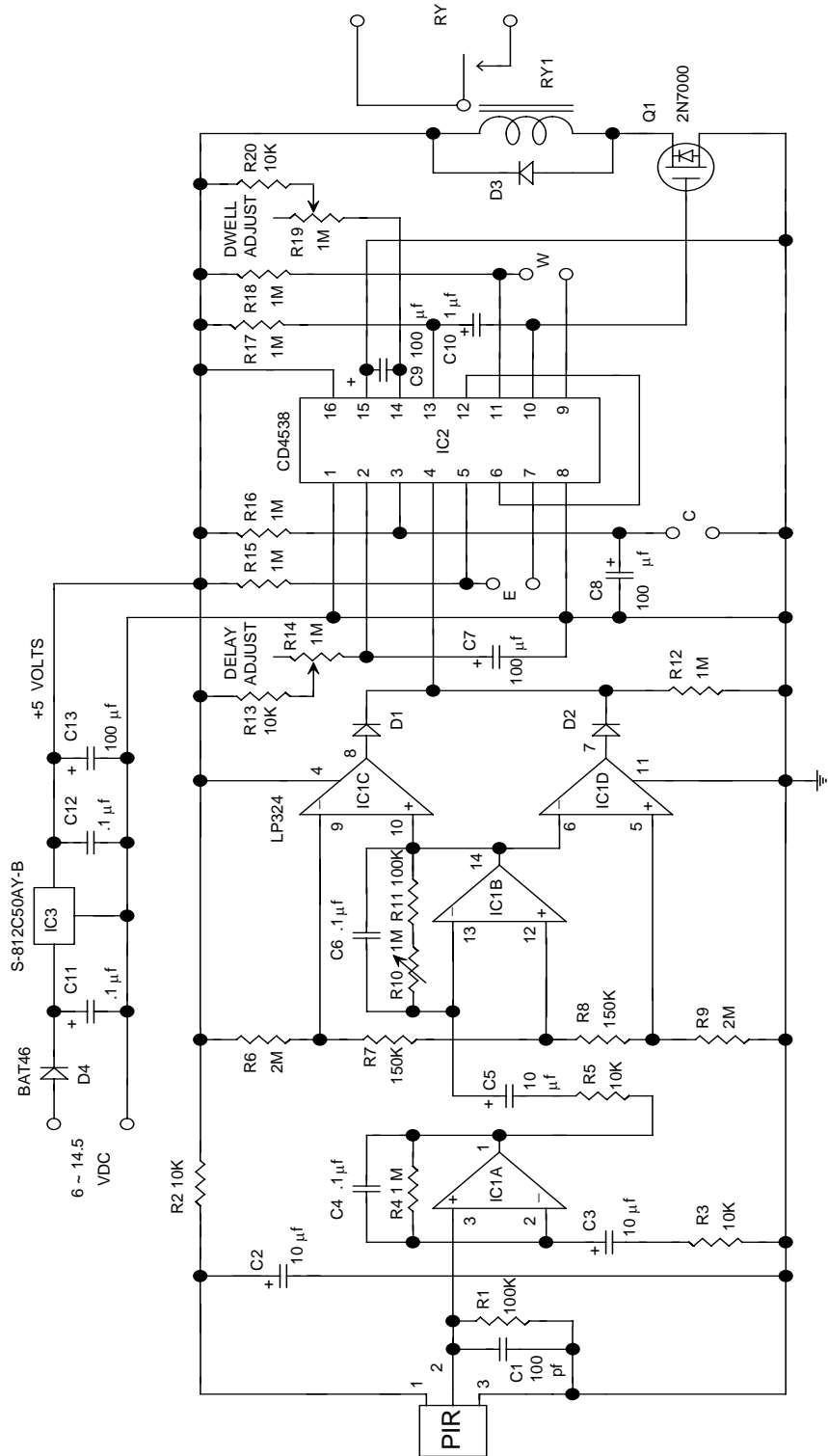


FIGURE 1

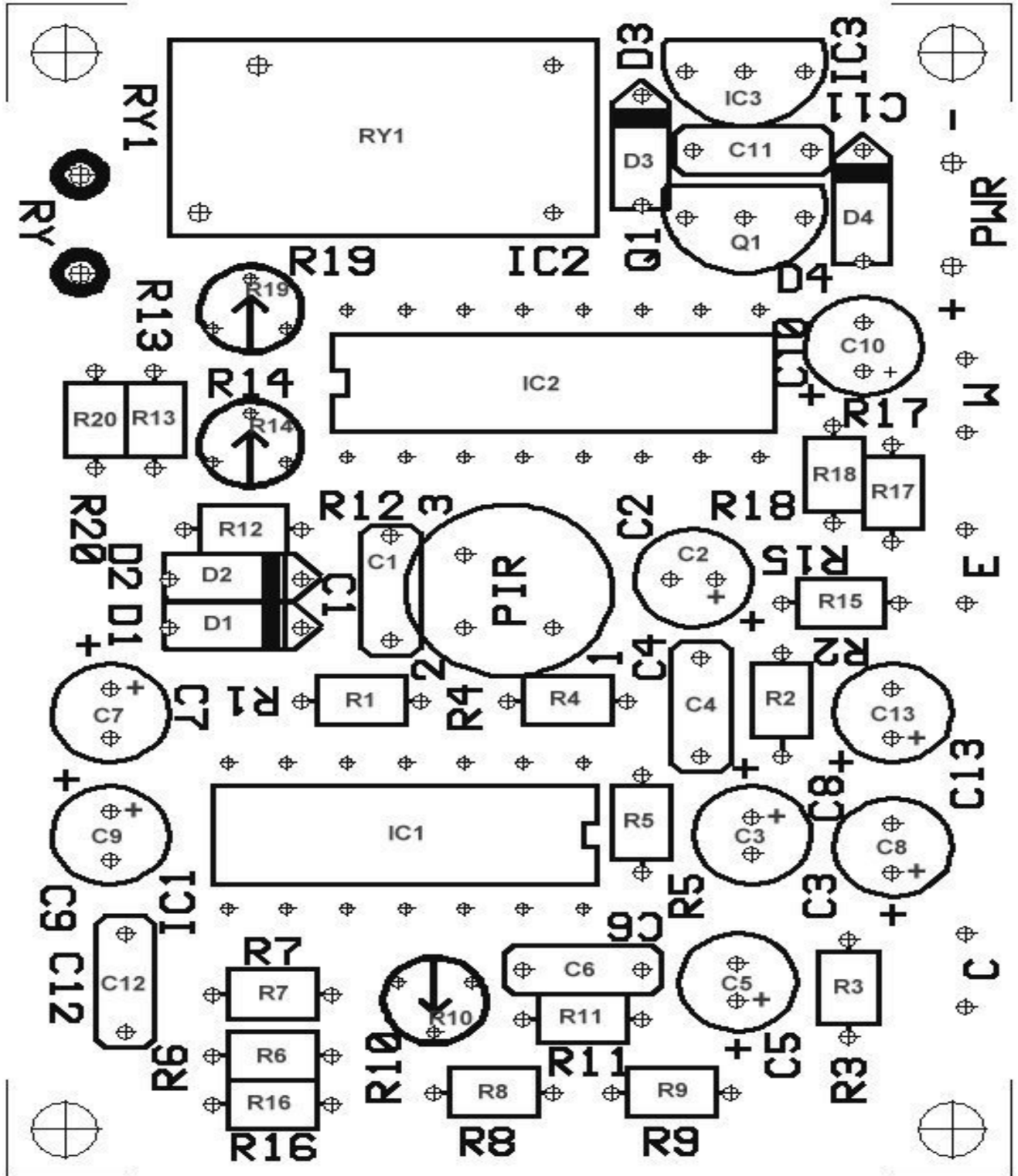


FIGURE 2

Soldering _____

When soldering to the PC board, use a small soldering iron of about 25 watts or smaller and small diameter rosin core solder. Touch the tip of the iron against both the component lead and the board metal where the lead touches the metal and apply solder between the tip of the iron and the board metal. The solder will melt where it touches the iron and immediately flow onto the component lead and the board metal and it will then help to transfer heat to the joint. You can now apply a little more solder to other areas of the joint if necessary.

Do not apply just heat to one side of the joint and solder to other side as some soldering instructions tell you to do as this will result in overheating of the joint before the solder melts, burning the flux and oxidizing the solder.

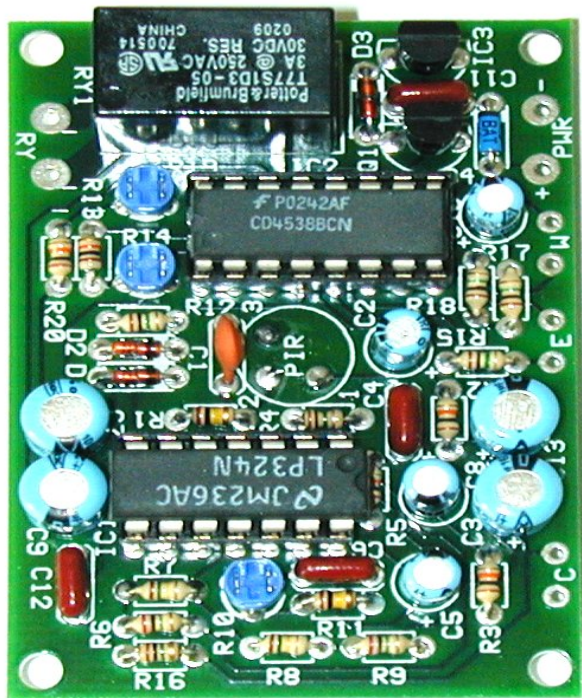
Assembly instructions _____

Refer to the schematic in figure 1 and the physical layout in figure 2 for parts placement.

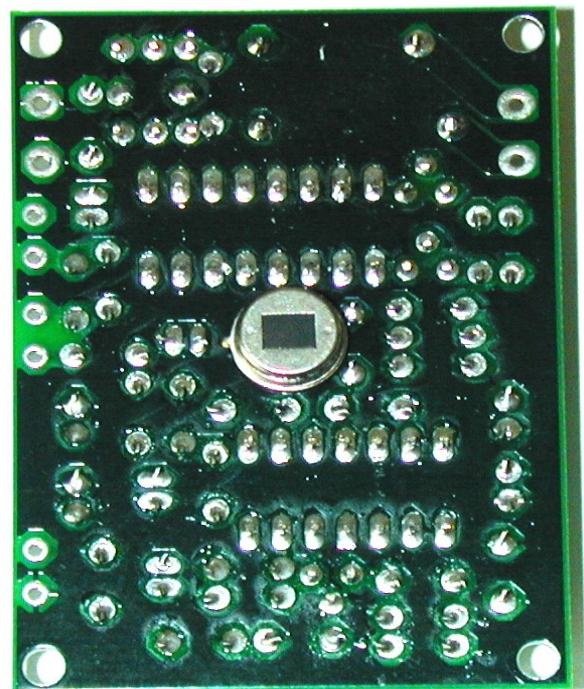
- 1 Bend the leads of all diodes and resistors close to the diode or resistor body, insert into the PC boards and bend the leads against the back side of the board. Cut the excess leads off short enough that they do not touch other connections but long enough to retain the diode or resistor until it is soldered. Be sure to insert diodes with cathode bands in the correct direction as shown on the boards. Solder all diode and resistor leads.
- 2 Insert each potentiometer R10, R14 and R19 with its wiper terminal (the one that is different than the other two) in the hole marked by an arrow on the PC board. Press the potentiometer in place and solder.
- 3 Insert small capacitors C1, C4, C6, C11, C12, bend their leads, cut excess wire off and solder.
- 4 Insert electrolytic capacitors C2, C3, C5, C7, C8, C9, C10, C13 with their long positive lead in the hole marked + on the PC board and in figure 2. Bend the leads, cut excess wire off and solder.
- 5 Insert transistor Q1 and voltage regulator IC3 in the direction indicated on the PC boards so they stand at least 1/8 inch above the board. Solder all pins and cut off the excess leads.
- 6 Insert IC1 and IC2 sockets with their notch as indicated on the PC boards and hold them against the board while soldering a few pins. Solder all remaining pins.
- 7 Insert relay RY1 and solder.

- 8 Place the O ring over the leads of the PIR325 sensor and insert the sensor leads into the bottom side of the board. Bend the leads over, cut off excess wire and solder. Do not overheat. Apply only as much heat as necessary for a good solder joint.
- 9 Carefully straighten the leads of IC1 and IC2 so they extend straight down and will fit into the sockets. This can be done with a pin straightener or by resting the IC on its side on a flat surface. Gently press on the IC while rocking it until the leads face straight down from the top of the IC. Repeat for the other side. Handle the ICs carefully to avoid static discharge damage.
- 10 Insert IC1 and IC2 into their sockets with pin 1 near the socket notch.

You are now ready to attach a battery or other power source to the + PWR – pads and a load to the RY pads. Allow about one minute for the circuits to stabilize after power is applied. You can also connect an optional photocell to the C pads for night only operation. Clockwise rotation of potentiometer R10 increases the amplifier gain, clockwise rotation of R14 increases the delay between motion detection and clockwise rotation of R19 increases the dwell time when the relay is energized. With the gain control R10 set fully clockwise for maximum gain and without a lens in front of the sensor, it will detect a moving hand at a distance of about one foot and a human body at about three feet.



TOP VIEW



BOTTOM VIEW

Pyroelectric Sensors

The sensor has two elements connected in a voltage-bucking configuration. This arrangement cancels signals caused by vibration, temperature changes within the sensor and sunlight. An animal passing in front of the sensor will activate first one and then the other element as shown in figure 3 whereas other sources will affect both elements simultaneously and be cancelled. The radiation source should pass in a horizontal direction so the elements are sequentially exposed to the IR source. The sensor also has a built-in infrared filter window.

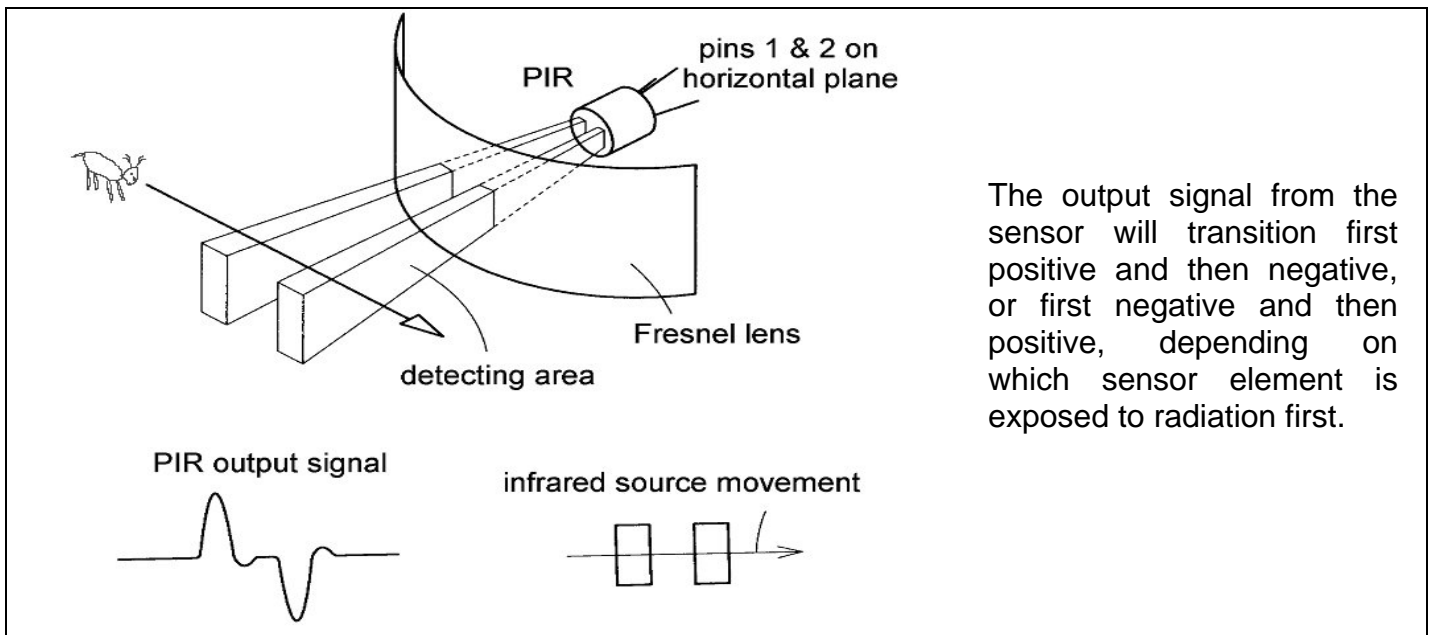


FIGURE 3

Sensor characteristics

The sensor will respond to a moving body only; it will not detect a stationary infrared source, however it is very sensitive to changes in air density close to the front of sensor and might produce false responses if not covered by a lens or IR transparent window. The detection range without a lens is about three feet but can be extended to up to 90 feet or more by placing an infrared Fresnel lens in front of the sensor. A Glolab FL65 infrared Fresnel lens with a focal length of 0.65 inch is recommended for longest range. The lens can be mounted in an enclosure with its grooves facing inside, using silicone rubber adhesive around the mounting flange. The GLMDA should be mounted with the FL65 lens spaced 0.65 inch from the sensor.

How the GLMDA works_____

Amplifier and comparator

Figure 1 is a circuit diagram of the GLMDA. Power is supplied to the circuits and to the relay through micropower 5 volt regulator IC3. The 5 volts from the regulator is further filtered through R2, C2 and fed to pin 1 of the PIR325 pyroelectric sensor. The signal output at pin 2 of the sensor is bypassed to ground by a 100pf capacitor C1 to shunt any RF energy that might be picked up from radio transmitters or cell phones. A 100K load resistor R1 is also connected from pin 2 to ground.

When motion is detected the sensor will output a very small voltage transition at pin 2. This voltage must be amplified many times in order to do useful work. Two sections of a LP324 or equivalent quad operational amplifier are used to provide the necessary amplification. Sensor pin 2 feeds into the first stage amplifier IC1A at non-inverting input pin 3. This is a very high impedance input and does not load the sensor. A high pass filter and feedback network, R4, C4 connects from IC1A output pin 1 to inverting input pin 2 and a high pass filter and bias network, C3, R3 connects from pin 2 to ground. These networks set the amplifier gain and operating point and also form a bandpass filter that amplifies only signals above DC and below about 10Hz. The pyroelectric sensor is a thermal device and its response time falls within this band of frequencies. Filtering out signals outside its response time eliminates noise sources from frequencies that are not used anyway and makes the amplifier more stable.

The output of the first amplifier stage, IC1A is taken from pin 1. It then feeds through R5 and C5 into the inverting input of the second amplifier stage at pin 13 of IC1B. C5 blocks the flow of DC and, together with R5, forms a high pass filter to reduce gain at very low frequencies. A feedback network R10, R11, C6 connects from IC1B output pin 14 to inverting input pin 13. R10 is a potentiometer that controls the amount of feedback and therefore the gain of this stage. R11 limits the amount of feedback. The non-inverting input to IC1B at pin 12 is biased to $\frac{1}{2}$ of the supply voltage or 2.5 volts by resistor divider network R6, R7, R8, R9. This bias sets the operating point of the amplifier so that its output pin 14 is at 2.5 volts when no motion is being detected.

The output of IC1B pin 14 feeds into a window comparator made of IC1C and IC1D. When an operational amplifier is used as a comparator It is run at full open loop gain so that its output switches to a full up or down level when one input is just a few millivolts higher or lower than the other. The purpose of this comparator is to provide a small voltage window or dead zone centered around 2.5 volts that will not respond to small voltage transitions caused by noise or minor fluctuations from the sensor. The inverting input of IC1C at pin 9 is biased by the voltage at the junction of R6, R7 so it is about 175 millivolts above the 2.5 volt output level at pin 14 of IC1B, and inverting input pin 10 of IC1C is connected to IC1B pin 14. IC1C will not turn on until pin 10 goes more positive than pin 9. The non-inverting input at pin 5 of IC1D is biased by the voltage at the junction of R8, R9 to about 175 millivolts below the 2.5 volt output level at pin 14 of IC1B, and inverting input pin 6 of IC1D is connected to IC1B pin 14. IC1D will not turn on until pin 6 goes more negative than pin 5.

When motion is detected and the voltage transition at the output of second stage amplifier IC1B pin 14 is positive it must go more than 175 millivolts above 2.5 volts or 2.675 volts in order to turn IC1C on so that its output will transition to a high level. If the voltage transition at IC1B pin 14 is negative it must go more than 175 millivolts below 2.5 volts or 2.325 volts in order to turn IC1D on so that its output will transition to a high level. The window comparator therefore provides a 350 millivolt dead zone centered around 2.5 volts within which it will not respond to voltage level changes from the amplifier. Any valid motion that is sensed will be amplified enough to generate a transition that will exceed this dead zone and result in a comparator output. Another characteristic of the comparators is that they each produce a positive output transition when they turn on whether the IC1B pin 14 amplifier output goes high or low. The comparator outputs at IC1C pin 8 and IC1D pin 7 feed into a logic OR circuit consisting of diodes D3, D4 and pulldown R12. The cathodes of D3, D4, that are connected together will go high whenever either IC1C or IC1D turns on. This amplifier and comparator circuit will therefore respond to both positive and negative transitions from the sensor.

Timing circuits

A CD4538 dual single shot performs two built-in functions and three optional functions. The built-in functions provide an adjustable delay between load activation when motion events are sensed and an adjustable dwell time to keep the load active even after motion stops. Optional functions are 1) retriggering of the delay so that repeat motion events will extend the delay between load activation, 2) retriggering of the dwell time so that repeating motion will extend the time that the load remains active, and 3) a day / night function to inhibit activation of a load during daylight.

Each of the two single shot circuits in IC2 has both inverting and non-inverting inputs and outputs. When motion is detected a positive transition at the cathodes of D1, D2 feeds into non-inverting input pin 4 of IC2 and triggers the first single shot on for a period determined by time constants R13, R14, C7. The non-inverting output at pin 6 goes high and remains high during the timeout period. Pin 6 connects to the non-inverting input pin 12 of the second single shot and its positive transition triggers that single shot on for a period determined by time constants R19, R20, C9, (dwell period). The non-inverting output at pin 10 feeds into NFET Q1 and turns it on which energizes relay RY1 and closes its contacts.

Both single shots are triggered on by a positive transition and not by a DC level. When the first single shot is triggered on, its output transitions positive and triggers the second single shot, however, it cannot trigger the second single shot again until its output goes low and then high again. The on time of the first single shot therefore produces a delay between repeat triggering of the second single shot. This is useful for applications where rapid repeat activation of a load is not desired such as when motion is continuously being detected.

When the second single shot is triggered on it keeps the relay energized for the dwell timeout period. This is useful for applications where it is desired to have a load remain active for some time after motion is detected.

Both single shots are re-triggerable. If the first single shot is triggered on by a positive transition from D1, D2, it will stay on for its time constant period and then turn off unless it receives another trigger before it times out. If it does receive another positive transition before it times out, its time constant components will be reset and the delay timeout will be extended by an additional delay period. Re-trigger is the default mode. If it is not desired, terminals E can be jumpered together on the PC board and the circuit will ignore trigger transitions that occur during its timeout period.

The second single shot will also re-trigger if it receives another positive transition at its input before it times out, however, it can only re-trigger if its timeout period is adjusted to be longer than that of the first single shot and if the first single shot delay is not extended beyond that of the second by re-triggering. Re-trigger is also the default mode of the second single shot. If it is not desired, terminals W can be jumpered together on the PC board and the circuit will ignore trigger transitions that occur during its timeout period.

A day/night function that inhibits activation of a load during daylight can be added by connecting a resistive cadmium sulphide photo cell to terminals C on the PC board. This type of cell has a high dark resistance and a low light resistance. In the default mode, reset pin 3 of the first single shot is pulled up to Vdd by R16. When a photo cell is connected from pin 3 to ground and its resistance is lowered by light, it pulls pin 3 down and resets the circuits so that they cannot be triggered on. The photocell is not polarized and can be connected in either direction. A switch may be connected in series with the photocell for daylight testing.

One end of the RY1 coil is connected to +5 volts and the other end to the drain of FET Q1. When Q1 turns on it conducts current through the coil of RY1 to ground and energizes RY1 causing its contacts to close. When Q1 turns off, the collapsing magnetic field of the RY1 coil attempts to produce a large positive voltage spike (back EMF) that would damage Q1 if not suppressed. Diode D3 clamps that spike and prevents back EMF damage. The RY1 contacts are normally open and they close when motion is detected. The contacts are rated for 3 amperes at 120 volts AC or 32 volts DC.

Current through voltage regulator IC3 changes rapidly from 40 milliamperes drawn mostly by RY1 when Q1 is on to only a few microamperes drawn by the amplifier and single shot circuits when Q1 turns off. The current change produces a positive voltage spike on the +5 power supply that can feed back into the amplifier and cause repeat activation of RY1 especially when the amplifier gain is set high. Filtering of the power system to completely remove such a spike is difficult without using a large capacitor so an alternate method of preventing feedback is used. Reset pin 13 of the second single shot is normally pulled up to Vdd through R17. Repeat activation of RY1 is prevented by C10 which pulls pin 13 to a down level when the gate of Q1 goes low and Q1 turns off. Pin 13 stays low for a period of about one second, determined by the time constant of C10, R17. If feedback does occur it will be ignored by the second single shot while it is in a reset state and all the circuits will have time to stabilize before reset pin 13 goes high again.



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