DIRECTION SENSING INFRARED MOTION DETECTOR MANUAL

GLDIR MOTION DETECTOR

GLOLAB

CORPORATION

Glolab does not offer a kit of parts for this project. We sell the PIR325 pyroelectric infrared sensor and FL65 Fresnel lens. Other parts are available from electronic parts distributors.

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 and RF 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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GLDIR ________________

Description

The GLDIR direction sensing motion detector is 1.7 X 2.4 inches with circuit components on one side and a pyroelectric infrared sensor on the other side. The board 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 GLDIR 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 GLDIR 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.

Time that load remains on

Single shot circuits control the amount of time that a load remains turned ON after motion is detected. ON time can be varied from 0.1 second to about 10 seconds by adjusting R15. The single shots are re-triggerable so that continued motion will extend the ON time.

Power

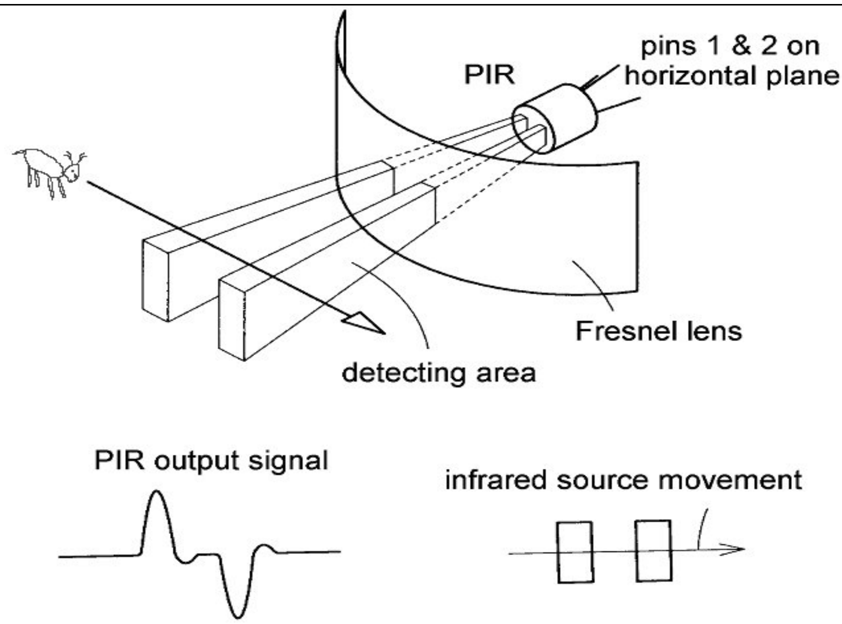
A 6 to 14.5 volt battery will power the circuits. Power is connected to the GLDIR solder pads marked “PWR, + and –“. The circuits draw less than 150 microamperes. A nine volt alkaline battery should power the motion detector circuits for several months and possibly much longer.

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 GLDIR, 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 GLDIR 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.

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 1 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.



The output signal from the sensor will transition first positive and then negative, or first negative and then positive, depending on which sensor element is exposed to radiation first.

FIGURE 1

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 GLDIR should be mounted with the FL65 lens spaced 0.65 inch from the sensor.

How the GLDIR works____________

Amplifier and comparator

Figure 2 is a circuit diagram of the GLDIR. Power is supplied to the circuits 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 ½ 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 that 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. Since IC1B is an inverting amplifier, IC1C pin 8 will produce a positive transition when the sensor output goes positive and IC1D pin 7 will produce a positive transition when the sensor output goes negative.

Timing circuits

The outputs from IC1C and IC1D feed into a CD4538 dual single shot. Each single shot has a normally low output that connects to a LEFT and RIGHT driver FET, Q1, Q2. Each single shot also has a normally high output. IC1C feeds through R12, into trigger input pin 12 of single shot IC2A and IC1D feeds through R13 into trigger input pin 4 of IC2B. The normally high output pin 9 of single shot IC2A is connected through diode D1 to trigger input pin 4 of IC2B and the normally high output pin 7 of IC2B is connected through diode D2 to trigger input pin 12 of IC2A.

When IC2A receives a positive transition from IC1C, its normally high output pin 9 goes low which pulls IC2B pin 4 low through D2 and prevents IC2B from being triggered while IC2A is still ON.

When IC2B receives a positive transition from IC1D, its normally high output pin 7 goes low which pulls IC2A pin 12 low through D1 and prevents IC2A from being triggered while IC2B is still ON.

Cross coupling of the normally high outputs to the trigger inputs allows the first single shot that is triggered ON to inhibit triggering of the other single shot and guarantees that only one output will be ON at a time. The time that the LEFT or RIGHT output remains ON after a single shot is triggered is controlled by the time constant R14, R15 and C7. This R/C network is connected to the timing input pins 2 and 14 of both single shots so that one network can be used to control the timeout period of both single shots. The single shots are re-triggerable. Continued motion during timeout will re-trigger the timing circuit and extend the timeout for one timeout period after motion is no longer detected. This can help prevent undesirable responses if an emitting body does not just enter and leave the sensing area.

Longer output ON time might be appropriate for applications such as indicating the direction that people move through a doorway or corridor while shorter ON time might be more desirable when the GLDIR outputs feed into a microprocessor for further processing or for special control functions.

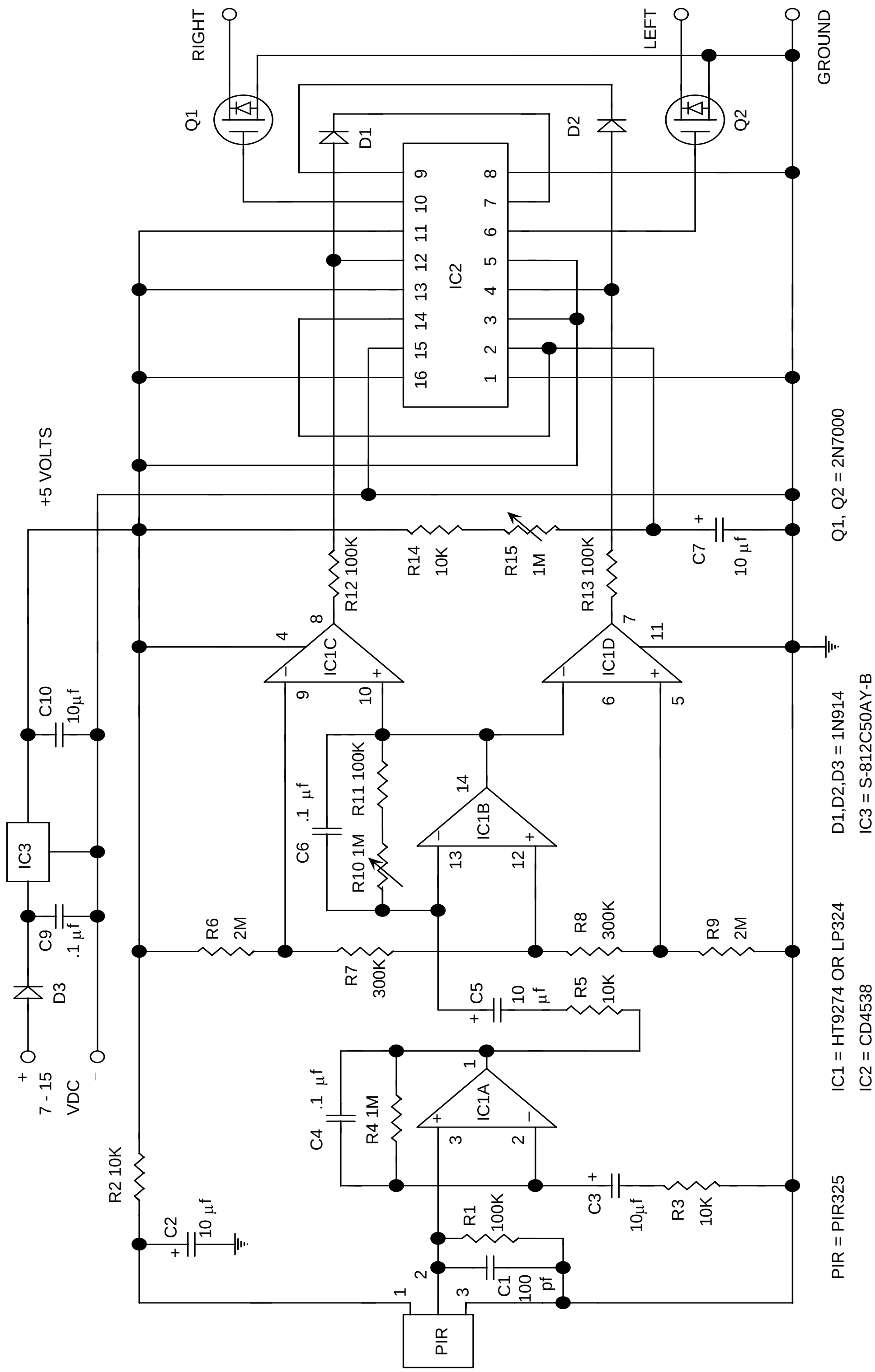

RIGHT
LEFT
GROUND
Q1
Q2
D1
D2
IC2
+5 VOLTS
Q1, Q2 = 2N7000
R12 100K
R14 10K
R15 1M
R13 100K
C7 10 μf
IC1C
IC1D
D1,D2,D3 = 1N914
IC3 = S-812C50AY-B
C10 10μf
IC3
C6 .1 μf
R11 100K
IC1B
R10 1M
C9 .1 μf
R6 2M
R7 300K
R8 300K
R9 2M
+ 7 - 15 VDC –
D3
C5 10 μf
R5 10K
IC1 = HT9274 OR LP324
IC2 = CD4538
C4 .1 μf
R4 1M
IC1A
R2 10K
C2 10 μf
C3 10μf
R3 10K
R1 100K
C1 100 pf
PIR
PIR = PIR325

FIGURE 2

ABSOLUTE MAXIMUM RATINGS

PARAMETER	RATING	UNITS
Power supply voltage [2, 3]	15.0	Volts
Load current [4]	0.2	Amperes

TYPICAL OPERATION

PARAMETER	MIN	TYPICAL	MAX	UNITS
Power supply voltage [2 3]	5.6	9.0	14.5	Volts
Load current [4]	-	-	0.2	Amperes

Notes:

1. Voltage from + to – power terminals on PC board
2. Reverse polarity protected
3. 40 VDC

GLDIR PARTS LIST

GLDIR PARTS DESCRIPTION	SOURCE	PART NUMBER
R1, R11, R12, R13 – 100K 1/8 watt 5% carbon film	Xicon	100K
R2, R3, R5, R14 – 10K 1/8 watt 5% carbon film	Xicon	10K
R4 – 1 MEG 1/8 watt 5% carbon film	Xicon	1M
R6, R9 – 2 MEG 1/8 watt 5% carbon film	Xicon	2M
R7, R8 – 300K 1/8 watt 5% carbon film	Xicon	300K
R10, R15 – 1 MEG potentiometer	Panasonic	EVM-L4GA00B16
D1, D2, D3 – 1N914 diode	Fairchild	1N914
C1 – 100 pf 50 volt ceramic disc	Xicon	50S5-101J
C2, C3, C5, C7, C10 – 10 MFD 16 volt electrolytic	Xicon	MLRL16V10
C4, C6, C9 - .1 MFD 50 volt metalized film	Panasonic	ECQ-V1H104JL
Q1, Q2 – 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	Glolab	PIR325
O RING – spacer	Polydraulic	BUNA-N size 009
IC socket - 14 pin	AMP	390261-3
IC socket - 16 pin	AMP	390261-5

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

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 and R15 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 C4, C6, C9, bend their leads, cut excess wire off and solder.

4 Insert electrolytic capacitors C2, C3, C5, C7, C10 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 transistors Q1, Q2 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. 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.

8. 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 straightner 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.

9. 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. Allow about one minute for the circuits to stabilize after power is applied. Clockwise rotation of potentiometer R10 increases the amplifier gain and therefore the detection range. Clockwise rotation of R15 increases the time that an output remains on after motion is detected. 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.

Installation

Connect a power source to the PC board power pads marked + PWR –. Connect loads to the PC board output terminals marked LEFT and RITE. **The output terminals are not a source of power for a load; they are open drain Field Effect Transistors that conduct current to circuit board ground when motion is sensed**. A load must be powered by an external source that will be switched OFF and ON by the FETs. A load should not be powered from the internal regulated 5 volt source that powers the motion detector circuits. If inductive loads are driven, they must be shunted by suppressor diodes to prevent damage to the FET drivers.

In addition to any other loads, a common anode bi-color light emitting diode or separate red and green LEDs can be connected to the outputs to indicate detected motion and direction. They can both be powered through one current limiting resistor since only one will be on at a time.

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 [4] p/n 1902GK or Mouser p/n 561-TSP37 [5] will mount the GLDIR PC board so that the sensor is the correct distance from the lens.

Note:

4. Digi-Key Corporation, www.digikey.com, 1-800-344-4539
5. Mouser Electronics, www.mouser.com, 1-800-346-6873

Operation

When infrared radiation is detected, the first exposure of the sensor will produce either a positive or negative transition, depending on which sensor element is exposed first. The sensor will output voltage transitions that usually repeat (ring) after the sensor's first exposure. The repeating transitions are usually of a lower amplitude than the first and include both positive and negative transitions. A single shot will be triggered by the first transition and ignore following transitions if the output ON time is set long enough. However, if the output ON time is short, undesirable responses can be reduced or eliminated by decreasing the amplifier sensitivity (detection range) until it is at the minimum required by the application. Reducing amplifier sensitivity will reduce the amplitude of any ringing that might occur.

The GLDIR performs well as a direction sensor and indicator, however it may not be useful for tracking the motion of an IR emitting body because it will not recognize static IR radiation.

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