

BADAX Home Security System

Independent Investigation: Magnetic and Motion Sensors

An easy to use and affordable home security system for your home.

The sensors that are used for home security and the possible limitations.

Team Members

Xavier Gallardo

Dan Shlyakhtin

Brian Sparacino

Author

Ashley Sukhavong

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Table of Contents

I. Overview	3
Introduction	3

II. Risk Specification	3
Customer Specification	3
Engineering Specification	3
Justification for Engineering Specification	3
III. Risk Investigation	4
Survey Existing Systems/Components	4
ADT Security Systems	5
Honeywell Security	5
Magnetic Contacts	6
Motion Detectors	7
Concepts Considered and Chosen	7
Rationale for Chosen	8
Analysis Performed	8
IV. Risk Mitigation Design	8
Technical Details of Proposed Design Chosen	8
How It works	9
Why the design mitigates	9
Detailed Design	9
Intellectual Property	12
V. Parts List	13
VI. Testing Strategy	14
Magnetic Sensor Test	14
Motion Sensor Test	15
VII. Uncertainties	16
A. Appendix	16

I. Overview

Introduction

There are many different sensors that are used within a security system. There are sensors that are needed to monitor the doors, windows and the different rooms within a home. The different sensors that a person uses to monitor a home is important. It is important to know which sensors are best used within a home since they all have their positive usage but also their

limitations. Individuals have to feel that the different entry points into a person’s home is going to be monitoring accurately and will continue to work efficiently. It is important to decide what type of sensors will still be affordable yet also perform the best.

Home security monitoring is not just to prevent homes from being homes from being burglarized, but to also prevent mishaps to happen within your home. There are many different feature such as home automation and other hazard detection that is offered within home security. Our security system’s main priority is to prevent homes from being burglarized, but many security systems offer other features. This high risk investigation is going to look at the magnetic and motion sensors that are used for home security. It will look at the different types of magnetic and motion systems and also figure out which is best for our home security system.

II. Risk Specification

Customer Specifications

1. Sensors should be used to detect when the entry point has been used
2. Sensors should be used to detect when there is a person in a room
3. Sensors should alert the system when the sensor is tripped when the system is armed
4. The sensors should be easy to install
5. The sensors should be affordable
6. The sensors should work accurately
7. The sensors should not be able to be disabled from outside persons

Engineering Specifications

- A. The sensor should be easy to conceal on the entry point
- B. The sensor should detect when an intruder has used the entry point
- C. The sensor should alert the system within seconds of detection
- D. The sensor should be able to protected from the elements and tampering

Justification of Engineering Specifications

Engineering Specification	Customer Specification	Justification
A	7	The sensor needs to be able to be concealed on the entry point so that the intruder cannot disable the sensor.
B	1,2,3	The system needs to respond quickly to when it detects entry or motion.
C	3, 6	The sensor has to be accurate and has to alert the system on

		time.
D	4,5,6,7	The system has to work and be protected from the elements and not be tampered with.

III. Risk Investigation

Survey of Existing Systems and Components

There are many different companies out there that specialize in security. These companies have similar features.

Security companies can offer:

1. Door/Window Sensors
2. Smoke/Heat Detector
3. Carbon Monoxide Detector
4. Motion Detector
5. Glass Break Detector
6. Safewatch Cellguard
7. Flood Detector
8. Low-Temperature Sensor
9. Heat Sensor
10. Indoor Sounder
11. Outdoor Siren and Strobe Siren
12. Wireless Remote
13. 24/7 Home Security Alarm Monitoring



Figure 1 The ADT home security kit

ADT Home Securities:

The most basic of the home security system offered is Essentials Plus which is mostly burglar monitoring. ADT offers these:

- 1 Safewatch Pro 3000 and Standard Touchpad
- 2 Hardwired Door/Window Sensors
- 1 Hardwired Motion Detector
- 1 Smart Voice Sounder
- 1 Power Supply and Battery Backup
- 6 ADT Window Decals and Yard Sign
- Total Installation: \$349.00
- Total Monitoring Fee w/ QSP: \$35.99



Figure 2 The Honeywell security kit

Honeywell Security:

One of the kits that are offered from Honeywell is called the Lynx Touch Wireless Alarm System - L5000 which includes:

- 1 L5000 Lynx Touch Wireless Alarm System
- 1 GSMVLP Cellular Communicator
- 1st Month of LiveWatch Total Connect Service
- 2 5815 Wireless Door/Window Sensors
- 1 5800PIR-RES Wireless Pet Immune Motion Detector
- 4 Window Stickers
- 1 Backup Battery
- 1 Power Cabling
- 1 Power Supply
- Total Kit Cost: 399.99

Magnetic Contact Switch

Magnetic contact switch is an electrical switch that is operated by a magnetic field. When there is an absence or presence of a magnetic field, the switch is either open or closed. Magnetic contacts are the most common form of protection. There are three types of magnetic contact: recessed, surface and mechanically actuated.



Figure 3 Recessed magnetic contacts

Recessed contacts are used within residential applications. The switch and magnet can be concealed within parts of a building and put into holes. They are raised dots among a surface and can be difficult to locate.



Figure 4 the surface magnetic contact

Surface contact is an associated magnet where both switch and magnet are visible after installation. They are good for use where recessed mounting is not an option.

Mechanically actuated switches are recessed contact which require physical operation to function. They can be rollers, push buttons and dome type contacts. The switch and magnet are integral to contact and actuated by a device to tell whether it is open or closed. They can sometimes fail over time.

The cost of magnetic contact switches can range in cost from very inexpensive (a couple dollars) to very expensive depending on what other features you want along the magnetic switch.

Motion Sensors

A motion detector is used to observe whether or not there are moving objects or people. A detector is often used to alert the user if there is motion within an area. The motion of a person or object is an electric signal that is measured by looking at the optical changes in the field of view. There is a range of 15 to 25 meters for most motion sensors. These motion detectors can be attached to alarm systems.

There are four types of motion sensors: passive infrared sensors (PIR), Ultrasonic, Microwave and Tomographic.

PIR: They detect body heat and there is no energy that is emitted from the sensor.

Ultrasonic: They are active (emit energy) and send pulse of ultrasonic waves and measure the reflection of off moving objects.

Microwave: They are active (emit energy) and send microwave pulses and measure the reflection of moving objects similar to a police radar gun.

Tomographic: They are active (emit energy) and sense the disturbances to radio waves as they try around by mesh network nodes. They can detect through walls and obstruction.

Concepts Considered and Chosen

The main focus of our security system is making sure that we can prevent homes from being burglarized and theft from occurring. Our main focus is making sure we can monitor the entry points to the home. The entry points to the home are doors and windows. The second focus is making sure to also monitor the movement within a room in your home. If by chance an intruder has bypassed a sensor at the entry points then the overall room sensor should be used to alert the homeowners of an intruder when the alarm system is armed.

While other home security systems offer more options to protect a person's home, we are focusing for now on the main entry point sensors. Most home security systems, the sensors on their windows and doors are magnetic contacts and the first barrier in home security. Therefore our main choice for door and window sensors are magnetic contact sensors. The second part of home security is if the first barrier fails, the second should be able to detect the motion of an unwanted person when the system is armed, which is where the motion detector comes in.

Besides motion sensors, there were other the considerations such as using laser sensors where if the path of the laser broke that would mean that the area was intruded upon. The path of the laser could have been used with mirrors to direct the path so that if the path was broken it would send a signal to the user. Another concept was to use a security camera that would monitor the room and then we would use digital image processing to determine the state of the room.

Rationale for Choices

Our group has decided to use magnetic contact switches for the doors and windows of our home security system. The system will also use motion sensors to monitor the rooms within the home for intruders. The type of magnetic switch that we will use will be surface. The reason why we have decided to use magnetic surface contacts is because they will be easy to install onto windows and doors without drilling into the fixtures themselves. Recessed magnetic switches need to be put into the fixture and we don't want to do damage to the foundation of the door or window. The motion sensor that we have decided to use is the passive infrared sensor (PIR). The reason why it was decided because it doesn't require excess energy from the sensor. The PIR can detect body heat and it is the least expensive system to install and implement.

Analysis Performed

The surface magnetic switches are going to be used because we cannot drill into the door and we are going to need to create a circuit which the magnetic switch is attached to a wireless transmitter. The wireless transmitter will tell the security system the status of each of the entry ways that have magnetic switches on them. The size of the complete magnetic door/window sensor with wireless transmitter might not work out to being small enough to be put into the door/window fixture. We also want the system to be easy to install. The reason we are using passive infrared sensors is because we're trying to save on energy consumption. The other motion sensors emit energy. We also want it to be easy for us to install and program and it might be hard to measure the reflection of moving objects. PIR sensors can be adjusted by height for smaller animals and small children.

IV. Risk Mitigation Design

Technical Details of Proposed Design Choice

We are going to use magnetic contact switches that have an 1 inch operation gap. This means that the gap between the magnet and the switch to have a working magnetic field is 1 inch. The magnetic contact is also going to be a closed switch network. It means that when the contacts are within the 1 inch gap of one another it means that the magnetic switch is close. When the contacts move more than 1 inch away from one another that means that the switch is open.

We are using a PIR motion detector because most intruders are humans and they have body heat. The PIR motion detector will be able to observe body temperature of a person. It is pretty hard to hide your body heat and also avoid the range of an accurately positioned motion detector.

How it works

The magnetic contact switches are easy to install and you can mount/attach part of the switch to the window and another to the sill. The magnetic contact switches also have a protective layer that protects it from the elements and certain temperatures. This will guarantee that the magnetic sensor will work all year around. The magnetic contact switches are also fairly inexpensive.

The PIR motion detector is easy to install and use. It will monitor the room for changes and then let the rest of the circuit it is attached to know. The PIR motion detector is also relatively cheap compared to other motion detectors.

Why the design mitigates

The magnetic sensors will act as the first physical barrier of intruder detection within the home. The magnetic sensors are easy to install and fairly cheap. They are pretty accurate up to a certain distance as long as the magnetic field is not disturbed. It is unlikely that an intruder outside the home will be able to adjust or manipulate the magnetic contacts connection with one another. The only way that would happen is if they decide to try to cut their way into the window and make a grab at both parts of the magnetic contact and switch.

The PIR motion sensor will also detect intruders by their motion if they somehow manage to get through the first line of defense. It is inexpensive to install and put in a room. It is small and doesn't take up a lot of space and it will be far away up high for the intruder to neutralize.

Detailed Design

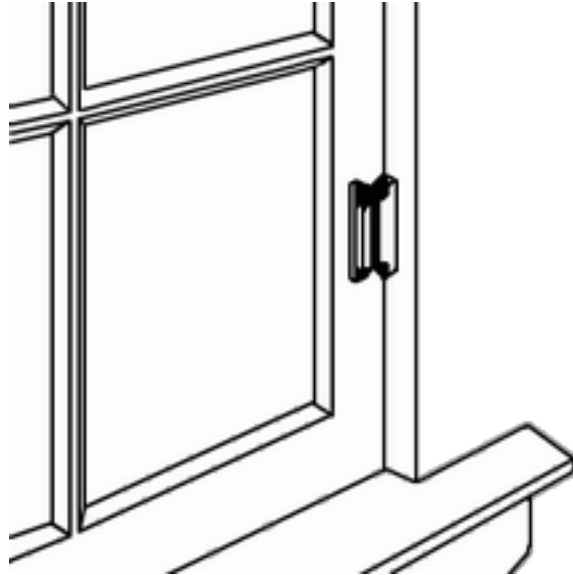


Figure 5 A picture of a window with a surface magnetic contact

This shows the typical installation of a magnet sensor on a window. It will be similar on a door where there is a certain distance the magnet and the switch will be. If the window slides open or if the door swings open, it will be detected.

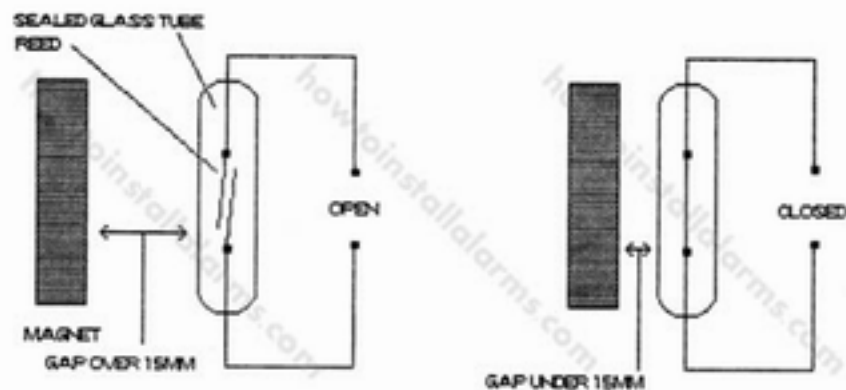


Figure 6 A circuit diagram of of the magnetic contact

There are two pictures of a magnetic contact that is closed and open. This also shows that there is a gap between the magnet and the reed. There is a max gap distance which the magnet field is active for which the sensor is closed.

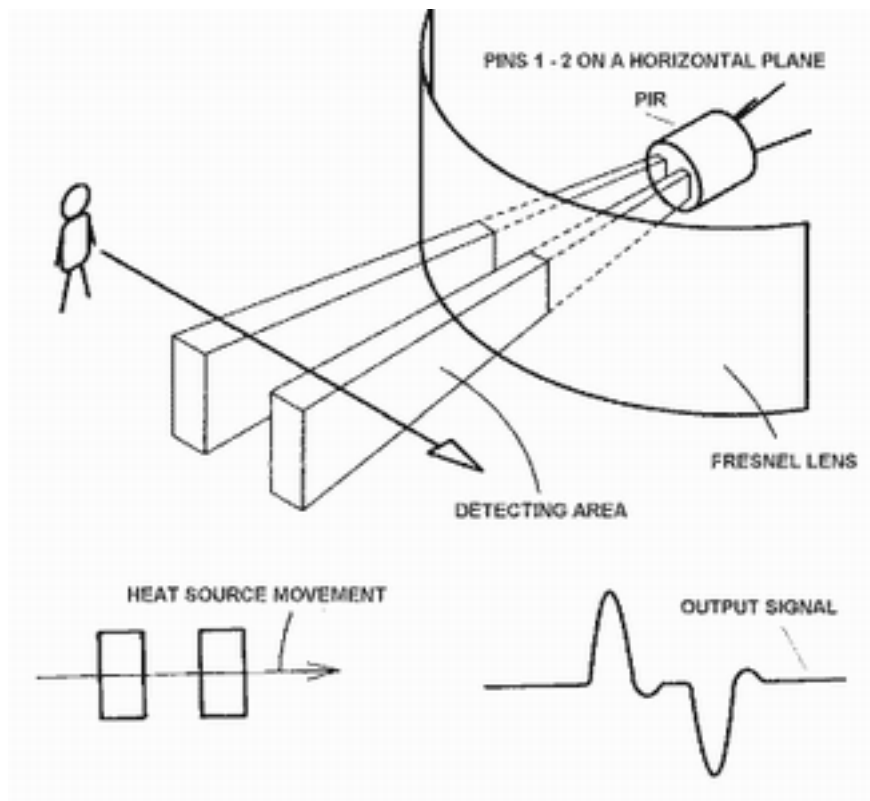


Figure 7 This shows the image of how the PIR motion detector works.

This shows the overall configuration of the PIR motion detector. The Fresnel lens helps filter out the thermal energy.

TYPICAL CONFIGURATION

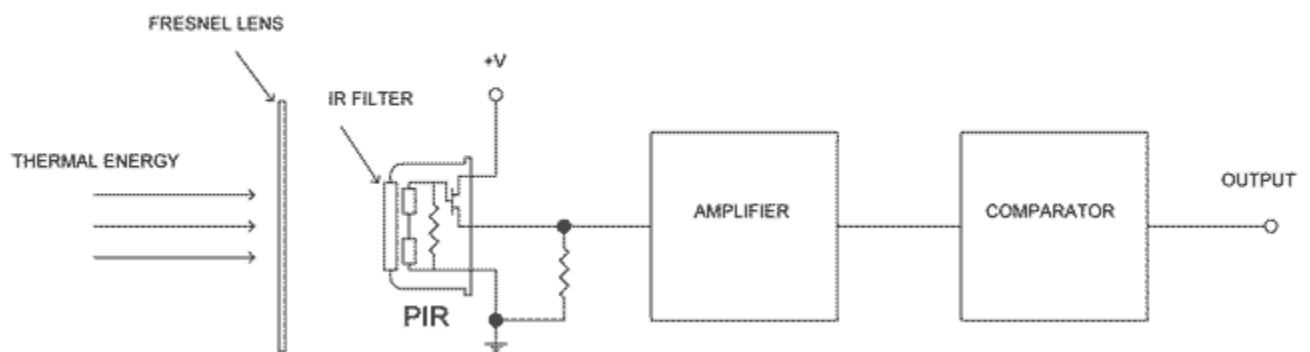


Figure 8 This shows the circuit configuration of the PIR motion detector.

The thermal energy is detected and filtered by the PIR and connected to an amplifier. The signal is put through a comparator to see if it matches what it previously scanned and results outputted. The output will be connected to a transmitter.

ITEM		Specification	Unit	Condition
Sensor Type		Dual Element		
Housing		TO 5		
Element Size		2×1	mm	
Spacing		1	mm	
Responsivity	Min Typ	3.2 4.0	xv/w	7...14mm, 1Hz, 100°C (One element cover)
Match	Max	<10	%	7...14mm, 1Hz, 100°C (Both element expose)
Noise	Typ Max	20 50	μVp-p V	25°C, 0.4...10Hz
Effect Voltage	Min Max	0.2 1.5		Re=47XO
Window Material		Silicon, coated		
Spectral Range	Transmission Blocking	T>30 average T<0.1	%	7...14mm <5mm
Operating Voltage		12	V	
Operating Temperature		-10~40	°C	
Storage Temperature		-40~80	°C	

Figure 9 A chart of the PIR motion detector specifications

This is some of the technical data specifications of the specific PIR motion detector that is going to be used by the security system.

Intellectual Property

Since we are not making our own surface magnetic contact switches or PIR motion sensor, they will belong to someone else, and we would have to pay for the parts to use them.

Patent US4038620 - Magnetic reed switch

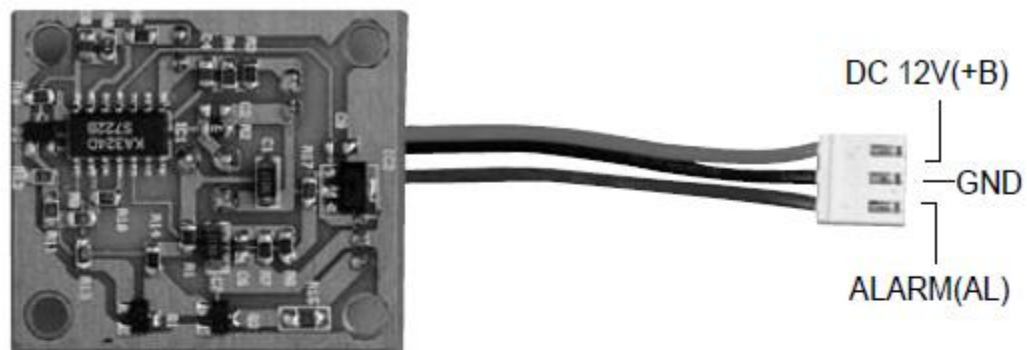
Patent US4857841 - Proximity detector employing magneto resistive sensor in the central magnetic field null of a toroidal magnet

Patent US6093915 - Magnet and *reed switch*/lock

Patent US3736584- Motion detector and intruder alarm

Patent US5867099 - Motion sensing, lighting and alarming system

V. Parts List



• BACK SIDE



• FRONT SIDE

Figure 10 The image of the PIR Motion Sensor to be used in the system



Figure 11 This is a picture of the surface magnetic contact to be used

Part Name	Distributor	Cost Each	Quantity	Availability
PIR Motion Detector	Sparkfun	\$9.95	1	Yes, In Stock, Standard Shipping Time
Seco-Larm Enforcer Magnetic Contact	Home Controls	\$2.55	3	Yes, In Stock, Standard Shipping Time

VI. Testing Strategy

The first thing to do when we first get these parts is to make sure we understand how to use them. We will read through the data sheets to understand the limitations of the parts and also what they can do. We would need to set up small circuits with the magnetic contact switches and also with the motion detector.

Magnetic Contact Switch Test

To test the operation of the magnetic contact switches, we could mount the contact onto a window or door. We will have the window in the closed position and when we open the window, the magnet circuit should send a signal that the window is open. The same test can be done for the door. We can also just test the magnets themselves from the door/window. The range of a

magnetic field ranges from 1 inch to several inches and we can test the distance of the magnetic field is active by bringing the distance of the switch and magnet far apart.

Magnetic Switch Distance Test	Test Result (Pass/Fail)
.5 INCH	
1 INCH	
1.5 INCH	
2 INCH	

Motion Detector Test

To test the operation of the motion detector we can mount the detector in the different positions of a room and figure out what is best of the range of detection. We should have the motion detector connected to a system that will alert us if there was motion detected. We should test the range of the motion detector in all dimensions.

Motion Detector Position	Dimension From Motion Detector	Distance from Detector	Result of Detection (Pass/Fail)
1	X, Y, Z	1 ft, 0 ft, 1 ft	
1	X, Y, Z	3 ft, 1 ft, 3 ft	
1	X, Y, Z	6 ft, 3 ft, 6 ft	
1	X, Y, Z	1 ft, 2 ft, 1 ft	
1	X, Y, Z	3ft, 4ft, 3ft	
1	X, Y, Z	6 ft, 6 ft, 6ft	
2	X, Y, Z	1 ft, 0 ft, 1 ft	
2	X, Y, Z	3 ft, 1 ft, 3 ft	
2	X, Y, Z	6 ft, 3 ft, 6 ft	
2	X, Y, Z	1 ft, 2 ft, 1 ft	
2	X, Y, Z	3ft, 4ft, 3ft	
2	X, Y, Z	6 ft, 6 ft, 6ft	

Position 1 would be a upper corner near the ceiling of the room.

Position 2 would be in the middle of the side of the wall near the ceiling of the room.

VII. Uncertainties

There are some limitations with using magnetic contact sensors. The magnetic contact switches can be seen since they are mounted on the window or door. There is possibilities of the intruder could manipulate or damage the magnetic contact. There are some magnetic sensors that have been overridden by using stronger magnets than the contacts to interrupt the field. There are also limitations on using the PIR sensor. The PIR sensor has to be positioned in a good spot and angle to get the best surface area covered. It is possible for the sensor to also be interrupted and damaged if put in the wrong spot. You can falsely trigger the PIR sensor more often. The PIR might not detect a still person since they react to the change in the room. The PIR is unable to detect through cloth or cardboard. Also it detects movement in front of it from about 8 feet away.

A. Appendix

Information on magnetic contact switches

<http://www.diyalarmforum.com/diy-alarm-faq23/>

<http://howtoinstallalarms.com/articles/magnetic-reed-contacts>

http://www.tanealarm.com/magnetic_contacts_101.asp

<http://www.structuredhomewiring.com/TamperProofWiring.aspx>

http://www.digikey.com/Web%20Export/Supplier%20Content/Magnasphere_735/PDF/Magnasphere_Hist.pdf?redirected=1

Information on motion detector sensors

http://en.wikipedia.org/wiki/Motion_detector

ADT Home Security Essentials Plus

https://www.adt.com/shop/webapp/wcs/stores/servlet/ProductDisplay?storeId=10101&langId=-1&parent_category_rn=10112&catalogId=10101&categoryId=10112&productId=11401&special=-1

Honeywell Security Kit

<http://www.safemart.com/Wireless-Home-Security/Honeywell-L5000-Lynx-Touch-Wireless-Alarm-System-LYNX-TOUCH.htm>

PIR Motion Sensor

<https://www.sparkfun.com/products/8630>

<http://www.sparkfun.com/datasheets/Sensors/Proximity/SE-10.pdf>

<http://itp.nyu.edu/physcomp/sensors/Reports/PIRMotionSensor>

Magnetic Contact Sensor

<http://www.homecontrols.com/Seco-Larm-Enforcer-Magnetic-Contact-SESM204W>
www.homecontrols.com/homecontrols/products/pdfs/SE-SecoLarm/SESM204W_Specifications.pdf

Patents

<http://www.google.com/patents/US3205323>
<http://www.google.com/patents/US5867099>