University of Southern Queensland

Faculty of Engineering and Surveying

An Autonomous Bird Deterrent System

A dissertation submitted by

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Abstract

The need for an effective bird deterrent is important in many of today's industries. In the past there have been many attempts to develop a successful system with few achieving adequate results. The aim of this project was to develop and design an autonomous system that creates minimal disturbance whilst being effective in bird deterrence.

An initial investigation and evaluation into the current types of bird deterrent systems was performed and from this the method of deterrence for the designed system was selected. Once the conceptual design was completed the mechanical, electrical and software sections of the system were designed in detail and partially constructed to discover the effectiveness of the system.

During the initial implementation of the system, expected and unexpected problems in the design arose that needed dealt with. The encountered problems were then listed in each of there relative sections and supplied with solutions and suggestions for a design revision.

Once this system has been fully developed, it will provide a frame work for multiple types of deterrent with the possibility for use in a variety of applications.

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Timothy Lewis Clarke

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Signature

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Date

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TIMOTHY LEWIS CLARKE

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Chapter 1

Introduction

1.1 Objectives

The aim of this project is to design an autonomous bird deterrent system that is effective in deterring birds from areas such as airports, crops and public buildings. To achieve this, a study will be conducted into current bird deterrent systems in order to evaluate their effectiveness. Once this is finished, the most effective system will be selected from a criteria and combined with a tracking system to create an autonomous deterrent. Machine vision will be used in order to continuously track the movement of the birds in flight and the surrounding area. Once a design has been finalised, a prototype will be constructed and limited preliminary tests of movement tracking and deterrence will be conducted.

1.2 Background

Birds cause more damage to produce farms and orchards than any other creature. Each year birds destroy crops and cause farmers significant economic damage. Studies conducted at the New Zealand Plant Protection Society (Coleman & Spurr 2001) show that 87% of farmers surveyed had encountered crop damage from birds that was significant enough to be considered a problem. The extent of the damage in some of these cases was equal to 20% of the farmers total harvest for that year which led to large economic blows.

Coghlan (1990, vol.128, p. 48) in his article *Pigeons, Pests and People* refers to birds as "rats with wings" for the speed of which they can affect an area and transmit diseased spores through their excrements. Diseases such as AIDS, Toxoplasmosis, Listeriosis, Viral Meningitis, Encephalitis, Salmonella and Paratyphoid are readily spread in places of high pigeon population due to the amount of droppings produced. Along with the disease that they bring the aesthetic value of buildings is lowered by large amounts of bird habitation due to the amount of droppings and the added noise made during the early hours of the morning.

The Bird Strike Committee, USA (2001) has also found that bird damage annually causes $500 million of damage to aviation industry in the United States alone and has been the cause of 400 human deaths from bird- aircraft collisions. In 2003 alone there were 4300 bird-aircraft collisions reported by the U.S. Air force and an additional 6100 made by civil U.S. aircraft with 90% of the birds involved being listed on the endangered species list. This amount of damage has made the U.S. place a high priority on the development of a successful bird deterrent system to ensure the safety of its aviation industry.

Figure 1.2.1 Bird Impact on Light Aircraft (Source Unknown)

For these reasons humans have been trying to deter birds from farms and buildings with devices such as scarecrows which were first used in 1592 with varying success. Since then there have been significant improvements in bird deterrent technology, however an equal improvement in bird deterrence is yet to be seen.

Chapter 2

Bird Deterrent Systems

2.1 Visual Systems

2.1.1 Scarecrows

Visual bird deterrents are visual objects that are designed to represent a predator to surrounding birds as either a human or a larger bird. The most common visual deterrent and the oldest is a simple scarecrow. Scarecrows are designed to mimic the appearance of a predator to cause birds to leave their current habitation. Most scarecrows are human shaped, and are constructed from inexpensive materials.

In general, because scarecrows are motionless they only provide short term protection due to the fact that the threat they create is perceived rather than real. Once the birds in the surrounding area realise that there is no danger the scarecrow loses all its effect so much so that some birds have been found to associate with them favourably (Inglis 1980).

To achieve the greatest effectiveness, scarecrows must appear to be life like, be highly visible and must constantly change location to extend the length of their effectiveness (Bishop, McKay, Parrott, Allan, 2003). In the last few years several types of moving scarecrows have come into the market. An example of these is the spinning scarecrow as seen in figure 2.1.1. These "Whirly Ozidge" scarecrows are constructed of a reinforced PVC skin which is stretched over the aluminium frame and rotate in the wind around their central axis. The PVC skin is printed with an image of a human and a bright red and yellow panel to try to create the illusion of a threat to surrounding birds.

Figure 2.1.1 Rotating Scarecrows (Scaring Birds Website)

Another type of moving scarecrow is the Scarey Man® made by Clarratts. The "Scarey Man" is an 165cm plastic scarecrow that runs off a 12 volt car battery. The scarecrow rapidly inflates about every 18 minutes and lasts for 25 seconds. During its inflation period the Scarey Man® emits a high pitched wail, and if at night illuminates.(See Figure 2.1.2).

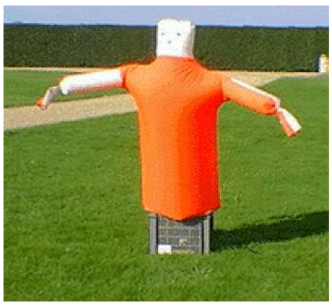


Figure 2.1.2: Scarey Man (Clarratts Website)

Ultimately, however lifelike scarecrows are, they do not pose a significant enough threat to scare birds. Therefore to improve the threat that scarecrows create it is recommended that these devices are combined with actual human activity or audio deterrents (Bishop, McKay, Parrott, Allan, 2003).

2.1.2 Corpses

An alternative method used to deter birds has involved deploying replicas or even actual corpses of birds in a way that signals danger. Birds often approach the corpse out of curiosity but leave when they see the unnatural position. Although this technique is inexpensive, it's effectiveness varies depending on whether the corpse is continually moved and the availability of alternative sites for the birds to relocate. As with most visual deterrents it is recommended that this device is used in conjunction with others to be successful for a significant period of time.

2.1.3 Kites

Hawk kites are mobile devices that act as a predators to create a threat to birds in the surrounding area. Most kites bear the image of a soaring eagle outline and are tied to the ground. Studies have shown that hawk kites are ineffective in deterring birds from crops (Conover, 1983) but however, are effective when flown beneath helium balloons to create a sufficient threatening movement.

Kites are generally easily damaged by strong winds and have difficulty staying airborne in air speeds that exceed 8 km/h (Hothern and Dehaven 1982). They also are only effective for a short period of time and over a small area.

There are also several other visual deterrents that are on the market today including mirrors, hawk-eyed balloons, large hawk eyes. These deterrents however are not as common or effective and are only suited to smaller areas.

2.2 Audio Systems

Audio deterrents are the most commonly used device in avian pest management. They operate by omitting either bird calls or ultrasonic sound waves to rid the surrounding area of birds. Most audio devices use either bird distress calls or predator calls and generate them randomly from different locations around the area.

2.2.1 Bio-Acoustic Devices

Bio-Acoustic deterrents are devices that transmit biological significant sounds such as bird alarm and distress calls. In nature, birds use alarm calls when they perceive danger, whilst distress calls are used when birds are captured, restrained or injured(Bishop, McKay, Parrott, Allan, 2003). Each call is species specific, however some distress and alarm calls are known to get a response from other species.

A number of different types of bio-acoustic deterrents are in the market today making them a common choice in bird control with some producing noise levels up to 110dB and having an effective distance of 300 m (Scarecrow Bio-acoustic Systems website). Bio-acoustics are seen as the most effective and cheapest ways of dispersing birds from airfields, once the equipment has been bought and staff trained (CAA 2002). In deterring birds from airports, the distress call is emitted for 90 seconds from a distance of 100 m from the target flock to keep reactions predictable.

Figure 2.2.1 is an example of the "Bird Chaser" system that uses a motion sensor to trigger distress and alarm calls.

Figure 2.2.1: Bird Chaser (www.pest-control.bz)

Bio-acoustics are the some most effective tools in bird control because the use the birds natural instinct to avoid danger as a deterrent. Their effectiveness is based on species-specific calls and the amount of alternative areas to move to that are in the area (Bishop, McKay, Parrott, Allan, 2003). However as with most bird deterrents systems such as these, they lose their effectiveness if they are not moved regularly and have their best results in combination with a variety of techniques.

2.2.2 Ultrasonic Devices

Other such bird deterrents such as ultrasonic systems which emit frequencies 21-26kHz in order to deter birds from areas such as warehouses, manufacturing plants, arenas, and loading docks. One of the current systems on the market is the Bird Chase Ultrasonic from Bird-B-Gone (Figure 2.2.2)

Figure 2.2.2 Bird Chase Ultrasonic (BirdBGone Website)

This system comes with 5 different program modes of ramp, blast, steady, sweep and random to discourage birds from the surrounding area. It also has 6 separate speakers and a claimed range of 500 square metres. Despite the superior features of this system the is no evidence that ultrasonic devices deter birds, with studies showing that most species of birds do not hear frequencies above 20kHz (Harris and Davis, 1998) giving no biological reason to use ultrasonics. Therefore ultrasonic systems are ineffective in deterring birds and use should be avoided.

2.3 Light Systems

2.3.1 Strobe Lights

Flashing, rotating, strobe and searchlights are novel stimulus to birds, which encourage an avoidance response (Harris and Davis 1998). Although stationary lights are known to attract birds at night, bright, flashing, revolving lights cause a blinding effect which causes confusion. Light systems are designed for deterring birds from roosting and feeding in specific areas and are most effective between dusk and dawn (Blackwell, Bernhardt, Dolbeer, 2002).

Studies conducted on light systems have shown that high intensity strobe lights caused birds to take evasive action and move away from some airfields (Pilo 1988). In the same study it was found that a randomised selection of two strobe frequencies increased the effectiveness over a range of species and that the strobes stopped all bird habitation.

Figure 2.3.1 BirdLite (Critter Ridders Website)

The above Figure 2.3.1 is the BirdLite, which generates coloured flashing light by rotating at various speeds and illuminating different sections of its outer case. Light deterrents such as the BirdLite are easy to deploy and require little maintenance, however should not be used in areas where they might cause a visual nuisance to surrounding properties. The are also no very effective during daylight hours and their ability to deter birds is species dependant. Light deterrents are best used with a combination of other methods.

2.3.2 Lasers

As the demand for non-lethal, environmentally safe methods of bird scaring has increased, interest has grown in the use of lasers, particularly low-power lasers that work under low light conditions (Bishop, McKay, Parrott, Allan, 2003). The low power levels, distance, accuracy and silence makes lasers an attractive choice when choosing a method of bird control.

The typical laser used in this deterrent type is a Class III B laser which has been found to be safe to use by the United States Department of Agriculture (Blackwell, Bernhardt, Dolbeer, 2002). The classification Class III B refers to lasers that have a power rating between 5 and 500 mW and are generally not capable of producing hazardous diffusion unless directly pointed at the eye.

Up until recently laser systems we used as either a human guided torch like the Avian Dissuader in Figure 2.3.2 or a laser field that covered a large area with little accuracy.

Figure 2.3.2: Avian Dissuader (SEA Tech Website)

Since then spinning and scanner laser systems are being and have been developed with a line scanning system currently being used at the Montpellier Airport in France. SEA Tech the developers of the Avian Dissuader are also conducting trials on a rotating laser in conjunction with the University of South Dakota and should have a commercial product in the near future (See Figure 2.3.3).

Figure 2.3.3 Prototype Rotating Laser (SEA Tech Website)

The use of lasers can be an effective method of bird scaring, although there is some evidence to suggest some birds are laser-resistant (McKay, 1999). Laser equipment is expensive and specialised training and safety precautions need to be in place in order for sound bird deterring practice to be achieved. As the effectiveness of the lasers decrease with increased light levels, their use in bird deterrence is only feasible from dusk till dawn and with hand held lasers requiring a user the overall cost of the deterrent is increased. New technology such as rotating and scanning laser systems has made obsolete, however these systems lack accuracy and the ability to keep non-target disturbance to a minimum.

2.4 Chemical Systems

2.4.1 Taste Repellents

Taste repellents can be divided into primary and secondary repellents. Primary repellents are agents that are avoided upon first exposure because they smell or taste offensive or cause irritation. Secondary repellents are not immediately offensive, but cause illness or an unpleasant experience. Following the ingestion of the secondary repellent, the bird then relates the taste to a unpleasant experience and avoids future encounters(Bishop, McKay, Parrott, Allan, 2003).

Using taste repellents is relatively expensive when compared to other deterrent devices due to the high cost of the chemicals needed and the labour and time needed to apply them. Taste repellents may however be an economically viable solution for small crop areas with studies showing that they are effective in lowering the level of bird damage.

For taste repellents to be effective regular spraying and persistence is required (McKay and Parrott, 2002).

2.4.2 Tactile Repellents

Tactile repellents involve the use of sticking substances that discourage birds because of their 'tacky' feel. They can be applied as clay-based seed coatings, or as pastes and liquids on ledges and other roosting structures to deter settling birds (Bishop, McKay, Parrott, Allan, 2003).

An example of a tactile repellent is the Hot Foot Repellent Gel (See Figure 2.4.1). It is opaque in appearance and has a lower toxicity than table salt.

Figure 2.4.1 Hot Foot Repellent Gel (Hoot Foot Website)

Tactile Repellents are time consuming to apply and although are not weather resistant can last up to a year in sheltered areas (Transport Canada 1994). They have found to be effective in preventing larger birds from perching on antennas but are less effective on smaller birds who require only a small area to perch.

2.5 Structural Systems

2.5.1 Wires

A common problem in large cities is the number of birds that roost on buildings and cover them in droppings. For this reason static structural deterrents have been developed and are used on many modern buildings. The main criteria in structural deterrents apart from deterring birds, is to be subtle and unnoticeable.

Overhead wires can be an effective method and low cost method of deterring birds. Many types of lines can be used but it is their spacing and height that appear to determine the bird species against which they are most effective (Bishop, McKay, Parrott, Allan, 2003). Wire systems can be relatively cheap to install and maintain, however require constant checking for broken lines that will be exploited by bird pests. They are a successful means of bird deterrence on large sites but are probably more effective on roof tops and ponds and small open areas.

2.5.2 Spikes

Spikes deterrents are made of strips of plastic or metal with upward pointing stainless steel or plastic spikes attached to ledges of buildings (See Figure 2.5.1).

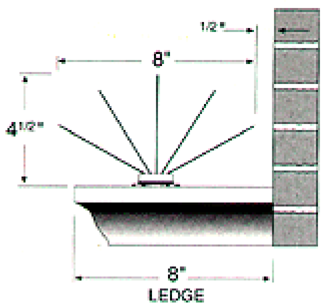


Figure 2.5.1 Bird Spike 2001 (Bird-B-Gone Website)

The spikes on these systems vary in length and orientation but act as a physical barrier to prevent birds from landing in all cases. These systems are relatively expensive and are easy to install however as with wires require constant checking to remove debris which may cover the spikes. Due to the sharpness of the tips and the danger they create this deterrent is illegal for use in some countries (Turner 1998).

2.5.3 Electric Track

Another commonly used deterrent is an electric shock track. The shock track works similarly to an electric fence with the track placed around the ledges of a building whilst an intermittent electric charge is passed through it. When a bird lands on the cable it completes the electric circuit and receives a mild shock. Manufacturers claim that the shock created induces the bird into giving a distress call which helps distress other birds (Transport Canada 1994). The effectiveness of electric shock tracks is similar to tactile repellents with a greater degree of success found with larger birds. Electric track systems are only effective over a small area and because of their dangerous nature are also illegal in some countries (Turner 1998).

2.6 Hybrid Systems

2.6.1 Gas Cannons

Gas Cannons are devices that produce loud banging noises by igniting flammable gases. The scaring effect they create is similar to the effect that firing a shot gun has on birds. The unexpected bang causes a 'startle' reflex and promotes the bird to panic and fly away (Harris and Davis, 1998). Inside the cannon the mixture of gas and air pressure is ignited at a frequency adjusted by the gas feed, or and electric timing device.

Most gas cannons produce noise levels up to 130dB at regular intervals, with some having additional features such as a double detonation or a rotator to change the direction of sound. They are commonly used in agricultural areas, but have been known to be used in aquaculture operations and on aerodromes (Bishop, McKay, Parrott, Allan, 2003).

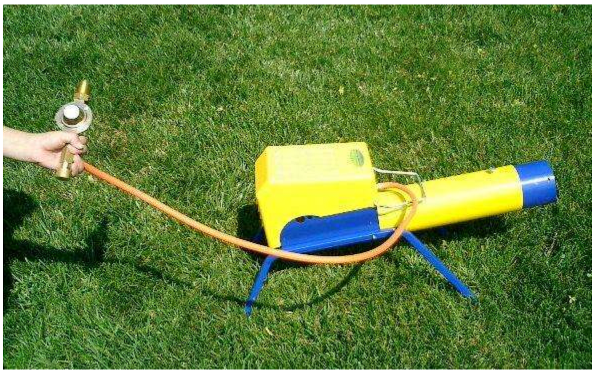


Figure 2.6.1 Propane Gas Cannon (BirdBlaster Website)

Gas cannons can be an effective means of bird deterrence if firing frequency and direction is varied and there is no noise nuisance concern in surrounding areas. Inglis

(1993) found that the intensity of sound output from gas cannons was highly variable between guns, and between explosions of an individual device. Conditions such as wind strength and direction played a large part in the intensity of the cannons.

Despite the amount of sound these devices produce they are relatively ineffective in deterring birds if they are moved or fired randomly and are not recommended for bird control by the Civil Aviation Authority (2002).

2.6.2 Other Devices

Another type of hybrid deterrent is the "Scarecrow" (See Figure 2.6.2). This deterrent is controlled by a motion sensor that sprays a jet of water once movement is detected. The shape of the "Scarecrow" is also designed to resemble a large predator bird to act as an additional visual deterrent. This device is relatively ineffective in scaring birds because its effective area is governed by how far the water jet can spray, and how far the sensor can detect movement. This device is best used very small areas such as residential gardens .

Figure 2.6.2: The Scarecrow, (BirdBGone Website)

One of the most complex bird deterrents on the market today is the “Bird Blaster” deterrent. This system uses a network of pressurised tubes that surround a Doppler radar that is used to sense birds in the surrounding area. At various locations in the tube are t-sections that have short pieces of tube that are controlled by solenoids. When a bird comes into the radar, the system controls the closest solenoid to the bird to open which in turn lets the pressurised air escape creating a hissing noise and a 'waggling' motion. This system tries to imitate a snake to induce a 'startle' reaction from the bird. Despite the autonomous nature of this deterrent system it is relatively ineffective in scaring birds because the length of the tubes do not create a significant enough threat.

2.7 Evaluation of Current Bird Deterrent Systems

2.7.1 Method of Evaluation

To evaluate current bird deterrent systems a set of criteria needs to be determined with a corresponding grading scale. As mentioned in the introduction the aim of this project is to design a system that is effective, and yet non-intrusive which makes these two criteria the most important. In this evaluation other factors such as cost, physical requirements and area covered will also be used to determine the best deterrent to undergo automation.

A ranked positional method will be used in this evaluation with each category being weighted out of a total of ten points by its importance and then a rating being given under each category out of five for each individual deterrent. The rating under each category is then multiplied by then importance factor at the top of the column, and the results summed for each deterrent. Once this is completed, averages can be calculated to determine the deterrent that best meets the criteria.

Due to the lack of testing and information of some types of bird deterrents the below table only takes into account 17 of the current commercially available deterrents with many values of area covered and cost being taken from suppliers documentation. In cases where little or no information was available the effectiveness and area covered results are only hypothesised values in comparison to the other deterrents.

The results of this evaluation are recorded in the Table 2.1 on the following page.

Table 2.1 Evaluation of Bird Deterrents

Name	Cost (1)	Requirements (1)	Area Covered (2)	Stealth (2)	Effectiveness (3)	Automation Ability (2)	Total (10)
Motion Sensing Water Spray	$74.95 4	Electricity, Water 2	140 m^2 2	Good 2	Poor 2	Fair 3	
Score	4	2	4	4	6	6	26
Taste Repellent Gel	$16.00 5	None 5	NA 2	Good 4	Poor 2	Very Poor 1	
Score	5	5	4	8	6	2	30
Wires	NA 3	None 4	NA 3	Good 4	Fair 3	Very Poor 1	
Score	3	4	6	8	9	2	32
Ultrasonic System	$225.00 3	Electricity 3	557 m^2 4	Good 4	Very Poor 1	Poor 2	
Score	3	3	8	8	4	4	30
Shock Track	Various 3	Electricity 3	NA 3	Excellent 5	Poor 2	Very Poor 1	
Score	3	3	6	10	6	2	30
Spikes	$220.20 3	None 4	NA 3	Fair 3	Poor 2	Very Poor 1	
Score	3	4	6	6	6	2	27
Hawk Kite	$59.95 4	None 4	NA 3	Poor 2	Fair 3	Poor 2	
Score	4	4	6	4	9	4	31
Hot Foot	$50.50 4	None 4	NA 2	Good 4	Fair 3	Very Poor 1	
Score	4	4	4	8	9	2	31
Corpses	$7.50 5	None 5	NA 1	Fair 3	Poor 2	Very Poor 1	
Score	5	5	2	6	6	2	26
Revolving Hawk Eyes	NA 4	None 5	NA 3	Poor 2	Fair 3	Poor 2	
Score	4	5	6	4	9	4	31
Movement Activated Audio Deterrent	$75.00 4	Electricity 3	100 m^2 2	Poor 2	Good 4	Fair 3	
Score	4	3	4	4	12	6	33
Doppler Radar Controlled Compressed Air Tube	Varying 2	Electricity, Air Compressor 2	930 m^2 4	Poor 2	Fair 3	Good 4	
Score	2	2	8	4	9	8	33
Propane Cannon	$790.00 2	Propane Gas, Spark Plug 2	NA 4	Very Poor 1	Good 4	Good 4	
Score	2	2	8	2	12	8	34
Scarey Man	$1240 1	12 Volt Battery 4	6 Ha 5	Very Poor 1	Good 4	Very Poor 1	
Score	1	4	10	2	12	2	31
Laser Deterrents	$1300.00 1	Electricity, Operator 2	500 m 4	Excellent 5	Fair 3	Good 4	
Score	1	2	8	10	9	8	38
Strobe Light	$250.00 3	Electricity 3	930 m^2 4	Poor 2	Good 4	Fair 3	
Score	3	3	8	4	12	6	36
Revolving Scarecrows	NA 4	None 5	NA 3	Poor 2	Fair 3	Very Poor 1	
Score	4	5	6	4	9	2	30
						<u>Average</u> =	530/17= 31.17

2.7.2 Results of Evaluation

From the above table, the two bird deterrent systems that best matched the criteria were the strobe light and the laser deterrent. Both deterrents scored above the average of 31.17 and scored well in most areas with the cost of the laser system being lowest scoring category. Therefore the decision on what deterrent to automate for this project was between the laser deterrent and the strobe light with each having its advantages and disadvantages.

Laser deterrents are an effective, silent, highly directionable and almost undetectable form of bird deterrent which could be easily automated. However this technology comes at a high financial cost of around $2000 per unit and also creates many safety issues when being used around humans due the Class III B power rating. It would also be very difficult to create an effective laser deterrent that could achieve the accuracy of a birds eye and to compensate for this a larger laser would be required which would also greatly increase the cost.

Therefore the strobe light has been chosen as the best deterrent to automate due to its relatively low cost, effectiveness and area covered. Due to the fact that strobe lights can cause a nuisance to neighbouring properties in open areas (Bishop, McKay, Parott, Allan, 2003) a directional strobe will be used in order to only effect desired areas. To achieve this, the strobe light will be placed at the focal point of a parabolic concave mirror in order to produce light only in one direction (See Figure 2.7.1 below).

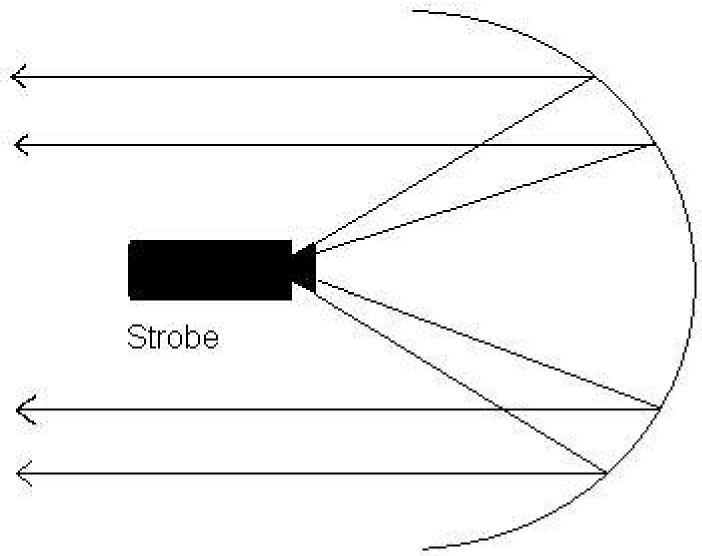


Figure 2.7.1 Directional Strobe Light

This strobe device will be main deterrent in the designed system and will be combined with a camera on a set of rotating and tilting axes to track a moving bird. The attachment of the strobe will be the final step in the construction of the deterrent before preliminary tests can be made.

Chapter 3

Machine Vision

3.1 Image Acquisition

Machine Vision is the use of computers to analyse situations and actions through the use of digitised video footage. To achieve this the images used must converted from film to digital information in order for a computer to process it.

3.1.1 Single Point Scanning

Single point devices basically consist of a light source and a light source detector which are used to determine the difference between two surfaces. The most common example of a single point scanning device is an optical mouse. The original optical mice that were created in the late eighties consisted of a focused beam of light that bounced off a highly-reflective mouse pad onto a sensor. The mouse pad had a grid of dark lines which the sensor then used as reference points to determine the amount and the direction of movement of the mouse. This kind of optical mouse was not very proficient to use, requiring the perfect angle between light beam and sensor to be accurate.

Current optical mice however use a tiny camera to take hundreds of pictures every second. The new optical mice use a small, red light-emitting diode (LED) to bounce light off that surface onto a sensor (See Figure 3.1.1). The sensor then sends each image to a processor for analysis which detects patterns in the images and compares those patterns to the previous image (Brain, c. 2001). The processor then determines the direction and distance that the mouse has moved from previous image and sends the corresponding coordinates to the computer.

Figure 3.1.1 Optical LED and Sensor (Howstuffworks Website)

Single point scanning devices such as the optical mouse are useful for applications such as line following and movement detection. They are most commonly used in small sized applications and can be very accurate. These devices are however not as effective for larger scale applications and therefore will not be used in this project to track birds in flight.

3.1.2 Line Scan Devices

Line scan devices use a small photo sensor with a lens and light to analyse images one line at a time. Perhaps the most common example of a line scanner is the modern fax machine. It works by reading one line of a document at a time and determining whether each point is black or white then turns that data in to information that can be sent via the phone line. Figure 3.1.2 is an example of what a line scan device ' sees ' when a capital E is passed by.

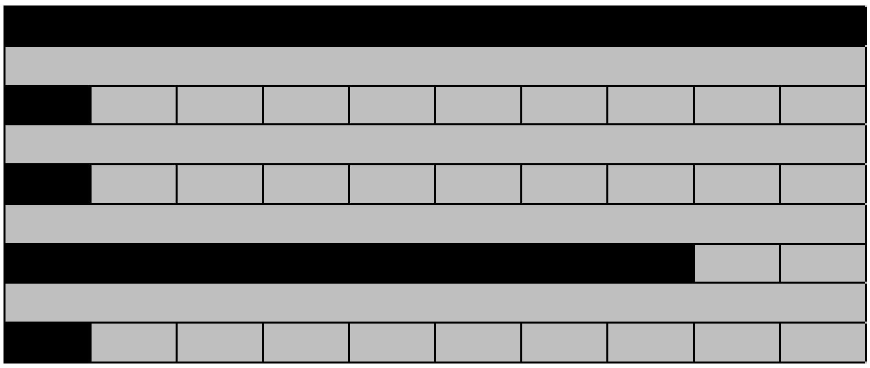


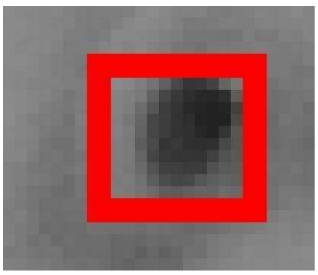
Figure 3.1.2 Line Scanned Image

Devices such as these are useful in manufacturing and bulk material handling with the ability to determine defects in parts or produce without having to calculate a two dimensional position. Line scan devices also have an advantage of quicker image analysis times over frame scan devices due to the relatively low pixel information per image. These devices are useful in determining shapes, sizes and discolourations of objects however are not useful in determining the location and therefore will not be used to track birds in this project.

3.1.3 Frame Scan Devices

Frame scan devices come in 2 main forms, a digital camera which requires a software buffer to retrieve image information or an analogue camera which requires a hardware frame grabber to digitise the information. In this instance web cams will be the only considered image capturing device due to their relatively low cost and ease of connection to most household personal computers.

Web cams use Complementary Metal Oxide Semiconductor (CMOS) technology in order to capture an image. They are very cheap to manufacture and use little power, but have a low light sensitivity causing them to only have low resolution. A CMOS camera uses a sensor that is made up of a collection of tiny light sensitive diodes called photosites that store charge that is proportional to the light which they receive. Once the photosites have received the light from the image they charge they create is then digitised be the web cam and sent via a Universal Serial Bus (USB) cable to the computer. Each pixel of the image is stored as a number in a array which is used to tell the computer what colour goes in what position. In a black and white camera the values of each pixel range from 0 to 255 with each value representing a different shade of grey (See Figure 2.8 below).



99	71	61	51	49	40	35	53	86	99
93	74	53	56	48	46	48	72	85	102
101	69	57	53	54	52	64	82	88	101
107	82	64	63	59	60	81	90	93	100
114	93	76	69	72	85	94	99	95	99
117	108	94	92	97	101	100	108	105	99
116	114	109	106	105	108	108	102	107	110
115	113	109	114	111	111	113	108	111	115
110	113	111	109	106	108	110	115	120	122
103	107	106	108	109	114	120	124	124	132

Figure 3.1.3 Digitised Gray Scale Image (Source Unknown)

For colour pictures, each pixel contains three values, relating to the amount of red, green and blue in that location. This is referred to as RGB which can produce almost any colour by using different amounts of red, green and blue.

Frame Scan devices are useful in determining shapes and movement of objects to a high degree of accuracy. They are superior to other image acquisition devices in the areas of locating and recognising objects however are the slowest due to the amount of information contained in each image. A frame scan device will be used in this project to locate a birds position relative to the camera with the possibility of also having the ability of recognise non avian movement.

3.2 Basic Image Processing

There are countless ways in which images can be processed to achieve a variety of different results. Through software processing computers can recognise shapes, patterns, objects, and movement to determine relevant information pertaining to a specific point of interest.

The most basic form of image analysis is image comparison. This technique compares RGB values in the current image to the previous with significant changes signifying a change or movement to the environment. Image comparison is very simple however requires constant updating of the image and fast processing times. Speed problems can occur with this technique when images are high resolution however the speed of the analysis can be increased easily by 100% by reducing the resolution of the image by half or by only sampling a every second pixel.

Another commonly used tools in image processing is edge detection. It can be done in a variety of different ways with the most basic form being the use of numerical filters. Numerical filters are 3 by 3 matrices that act as multipliers to pixel values in dual colour images. Below is a commonly used numerical filter for tracing around the edges of and object.

1	0	1
0	-4	0
1	0	1

Edge detection can also be done in a variety of other ways which include edge tracing methods or mathematical methods such as the Sobel edge detection. Edge tracing techniques are routines that which compare surrounding pixel values to a starting point and then follow the directions which are of similar values. By doing this lines of constant colour and light are drawn around objects which can be used for further analysis. Tracing techniques can used to generate graphs of direction of movement against length of movement which is a very useful technique in recognising shapes and objects.

Sobel edge detection is a mathematical technique which is used in many machine vision applications. It is similar to the numerical filters described before however uses two filters which are then used to calculate the edge gradient at each point. The filters used in Sobel edge detection are below with Figure 3.2.2 representing the magnitude of the gradient.

-1	0	+1
-2	0	+2
-1	0	+1

Gx

+1	+2	+1
0	0	0
-1	-2	-1

Gy

Figure 3.2.1 Sobel Filters (Fisher, Perkins, Walker, Wolfart, 2003)

$$|G| = \sqrt{Gx^2 + Gy^2}$$

Figure 3.2.2 Magnitude of Gradient (Fisher, Perkins, Walker, Wolfart, 2003)

The angle of orientation of the line relative to the pixel grid is then found using the following equation.

$$\theta = \arctan(Gy/Gx)$$

Figure 3.2.3 Angle of Orientation (Fisher, Perkins, Walker, Wolfart, 2003)

The Sobel image created using these equations can then be combined with a mathematical process called the Hough transform which is used to determine features in the image. The Hough transform can be used to identify the parameters of a curve which best fits a set of given edge points in order to extract the important information out of a picture. This method is rather complicated but achieves accurate results as seen in Figure 3.2.4.

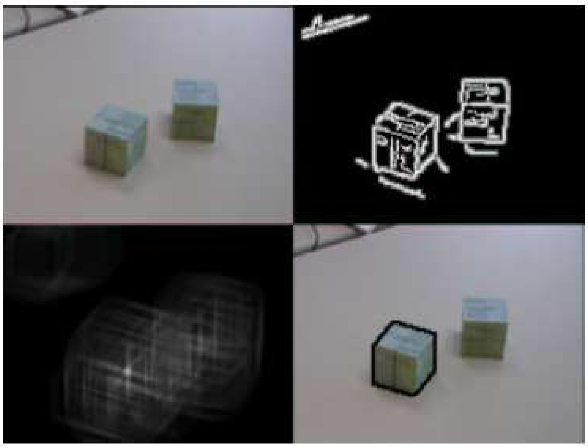


Figure 3.2.4 Example of Hough Transform (Strzodka, 2003)

3.3 Applications for Machine Vision

3.3.1 General Applications

Machine vision is a useful tool that can be used in a variety of applications. Through different image analysis techniques, machine vision provides opportunities to view images to either recognise objects, predict movement, measure dimensions, and/or record data. One of the most commonly used applications of machine vision occurs in the manufacturing and processing industry. Common examples in these fields are cameras that are used to detect defects in materials or products, and cameras that detect if there is an problem in the assembly lines. In these cases machine vision reduces inefficient production and ensures that products are of the highest quality.

Many modern medical operations use to machine vision to view areas which were formally impossible to view without surgery. This application of technology as been responsible for saving many lives and continues to broaden the abilities of medical doctors. Machine vision is also very useful in controlling and steering autonomous robots which are used today in many space and sea explorations. The other most common application of machine vision is in the area of surveillance and security. Examples of machine vision in this area are facial recognition and fingerprint recognition. This technology makes it almost impossible to gain access to areas due to the uniqueness of fingerprints and facial features.

3.3.2 Case Study

The following case study was conducted by James Matthews in 2003/4 to develop an intelligent closed circuit television (CCTV) monitor that would track individuals in a computer room. The system was also designed to determine whether individuals were stationary or standing and moving around the room.

From the initial observations of the test area, a few problems arose that needed to be dealt with. The problems were:

- **Periods of inactivity** - There were long periods of time where not much movement occurred among computer users.

- **Height and Blocking** - The height of the camera was relatively low which made it difficult to see all areas of the room and if someone was close to the camera other objects became hidden.

- **Movement** - As people sat down only very small amounts of their body could be seen and they also created movement in the same spot as someone in a different who was behind them.

- **Other Moving Objects** - When people got up off their chairs the rotation and lifting of the chair made it look like movement was still occurring at that computer

• **Screen movement -** Screen changes such as the screen savers on each computer were detected as movement

Examples of these problems can be seen in Figure 3.3.1 below.

Figure 3.3.1 Sample Screens for Observation (Matthews, 2003)

Although all of these problems are not common to vision applications an analysis such as this is useful to for see problems which could occur in bird scaring. Obviously problems such as screen savers will not be common in bird deterrence other instances such as trees moving in the wind and multiple movements or multiple birds must be considered.

To overcome these problems, functions and rules must be written so that only dark coloured objects are seen to be birds therefore tree movement is ignored. The instance of multiple birds can also be overcome by selecting the largest object because it is closest to the camera and hence the more important to detect. This stage of image analysis will need to be conducted once the basic operation has been finalised and tested.

3.4 Vision Applications in Bird Deterrence

As seen already there are large numbers of different tools and techniques that can be useful in the area of bird scaring. For this project however the focus will be first on image comparison and the later on edge detection and shape recognition depending on time. The device chosen for image acquisition was the Logitech Quickcam because it connects directly to a PC via a USB cable and has a digital output. The computer then receives the images and converts them into a digital byte in order for the image manipulation and analysis to occur.

The first part of the image analysis involves dividing the screen into nine separate sections each corresponding to a movement of the mechanical device mentioned in chapter four. Each section of the screen is compared to its previous image with the area with the highest amount of change containing the movement and hence bird location (See Figure 3.4.1). Once this system is stable and reliable additions such as edge detection will be made so that dramatic light sources such as strobe lights can can be used without creating a significant change in pixel values in all areas.

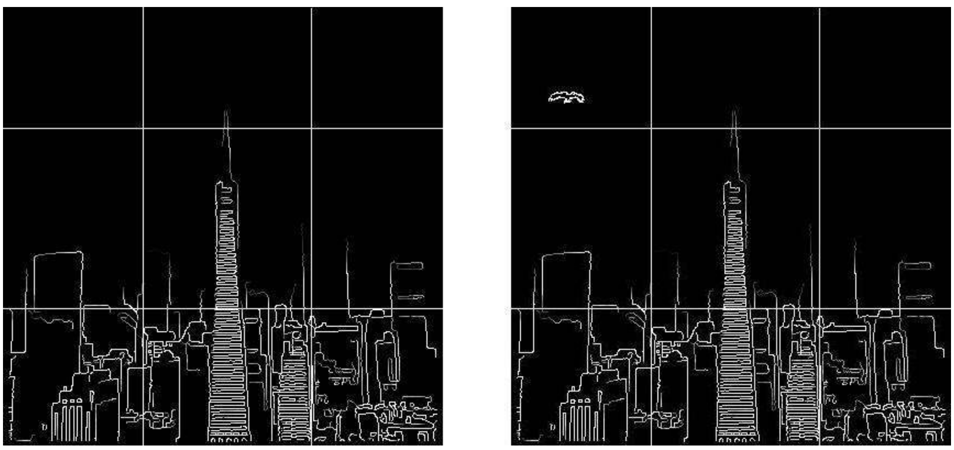


Figure 3.4.1 Edge detection showing movement in top left segment

Chapter 4

Mechanical Design

4.1 Conceptual Design and Requirements

The main conceptual design of this deterrent is to have a camera that is mounted on a mechanical system that can rotate and tilt to constantly have its target centred in its view of the camera. It must easily adapt to different types of deterrents such as the directional strobe light and laser deterrent and be able to connect to a PC. The movement required to move the camera and deterrent device must be able to be controlled by the computer and have switches that indicate the limits of movement. From these requirements the following device was conceptualised.

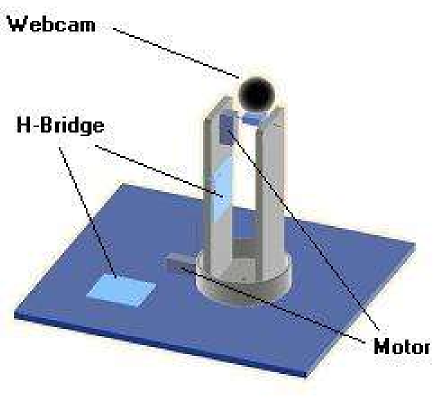


Figure 4.1.1 Conceptual Design

The camera captures the images and transmits them via the USB cable to the computer. After the image is analysed the computer, it then outputs a signal via the parallel port to the H-bridges (more detail in Section 4.3) that drives the motors in the desired direction.

The motor in the lower section is a geared DC motor which turns the shaft which is connected to the rotating base in a rack and pinion type configuration (See Figure 4.1.2 below).

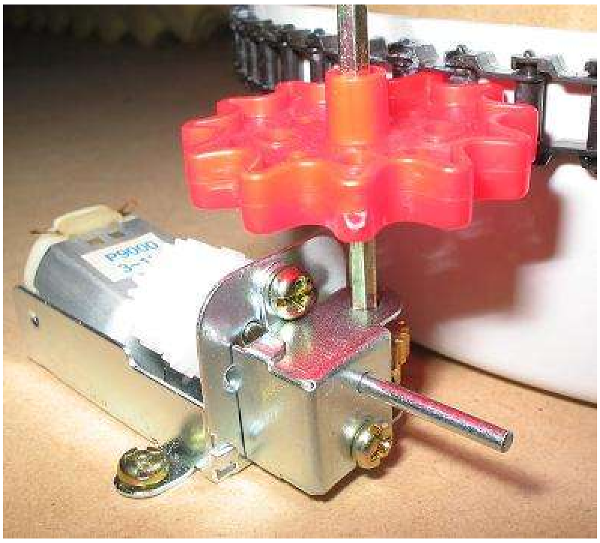


Figure 4.1.2 DC Motor and Gears

The motor in the upper section is configured in a similar way but with the output shaft being used to tilt a small platform to which the camera and eventually deterrent will be attached. Therefore the next step in the design procedure is to select the construction material, the type of motors that are needed, and the style of H-bridge needed. Once these components have been selected the electrical system schematic must be drawn and the design finalised.

4.2 Material Selection

The material selection for this project is not of a great importance because no critical loads are being carried and no significant force is created. The selection of the material was then mostly based on categories such as cost, availability, weight and workability. Light metals such as aluminium were considered but however, were not selected because of their ability to create electrical interference. Therefore MDF was chosen as the construction material because of its low cost (Approx $20/m$^{2)}$ and inert nature.

MDF or Medium Density Fibreboard is a type of hardboard that is made from wood fibres that are glued under heat and pressure (Lung 2004). It is dense, flat, stiff, has no knots and is easily machined. A list of its properties are in Table 4.2 below.

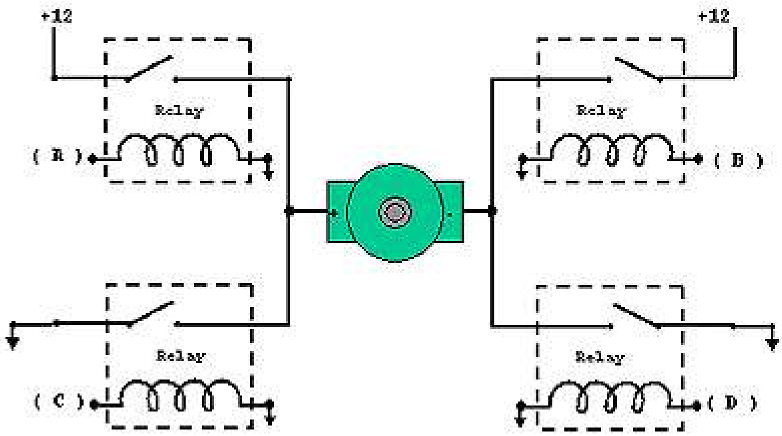
Table 4.2 Properties of MDF (EximCorp Website)

Thick Panel 12-21mm	**Unit**	**Value**
Density	Kg/CUM	720 - 740
Internal Bond	KPa	800
Modulus of Elasticity	MPa	3000
Modulus of Rupture	MPa	38
Screw Holding on Face	N	1100
Screw Holding on Edge	N	900
Moisture Content	%	6
Thickness Swell 24 hrs	mm	<1
Surface Water Absorption	g/Sq.Mtr	<80

4.3 H-Bridge

To drive a normal DC or Stepper Motor, both sides of a battery are connected to the both sides of a motor causing it to spin in one direction. When the poles of the battery are swapped the motor then spins in reverse. Pulsing the voltage and current into a motor on and off powers the motor in short burst and gets varying degrees of torque, which usually translates into variable motor speed. These facts are useful in many situations, however more often bidirectional motor control is needed in places where operation cannot be stopped to change terminals.

However to control the motor in both forward and reverse directions with a processor, a H-bridge is required (See Figure 4.3.1 below).



A	B	C	D	Function
1	0	0	1	Forward
0	1	1	0	Reverse
1	1	0	0	Brake
0	0	1	1	Brake
1	0	1	0	Fuse test :-)
0	1	0	1	Fuse test :-)

Don't do the fuse tests

Figure 4.3.1 Basic H-Bridge (Brown, 1998)

In the above figure drivers A and B are the relays that control the positive voltage to the motor called sourcing current. The C and D drivers control the negative voltage to sink current to the motor. As seen in the truth table above to spin the motor in one direction opposite corners of the H-bridge need to be turned on (See Figure 4.3.2 below).

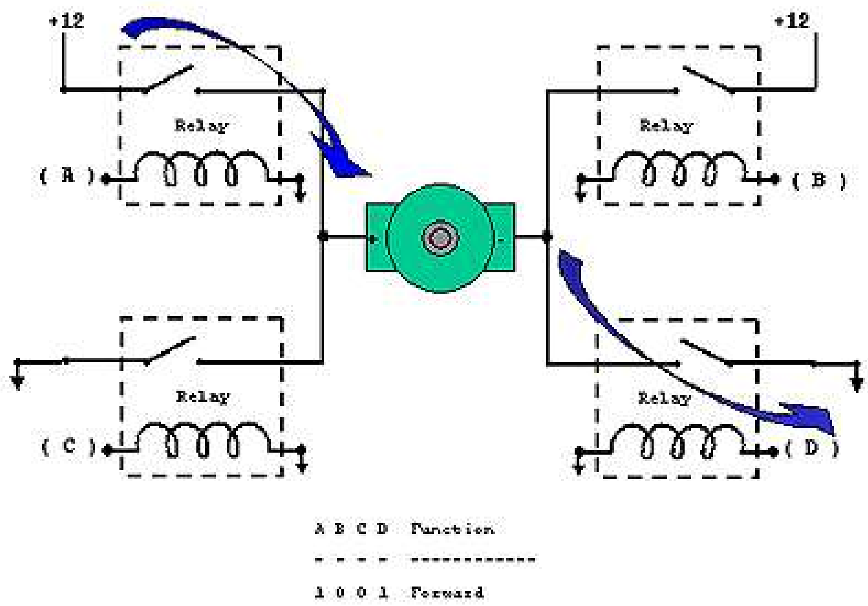


Figure 4.3.2 Forward Current Flow (Brown 1998)

By turning on both switches there is a current path from the +12V through relay A, through the motor to relay D and ground. The motor spin in the opposite direction is achieved by turning off A and D and turning on B and C. When all relays are turned on overheating occurs and the circuit is usually damage making it important to avoid that situation at all times. Turning both A and C relays should also be avoided because no current path is created and damage is likely to occur over time.

4.3.1 Transistor Driven

Transistor driven H-bridges operate in a similar way to the relay H-bridge in Section 4.3 with the relays replaced by PNP and NPN FET transistors. The PNP transistors in this case replace relay A and B due to the fact that P-channel FETs are good at sourcing current. Relays C and D are replaced with NPN transistors or N-channel FETs to be used to sink the current in the circuit. To protect the transistors from back EMF and burn out, a diode needs to attached across each transistor (See Figure 4.3.1).

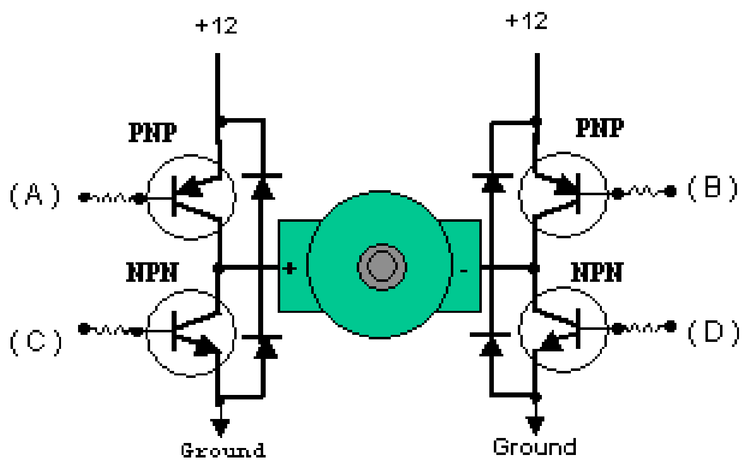
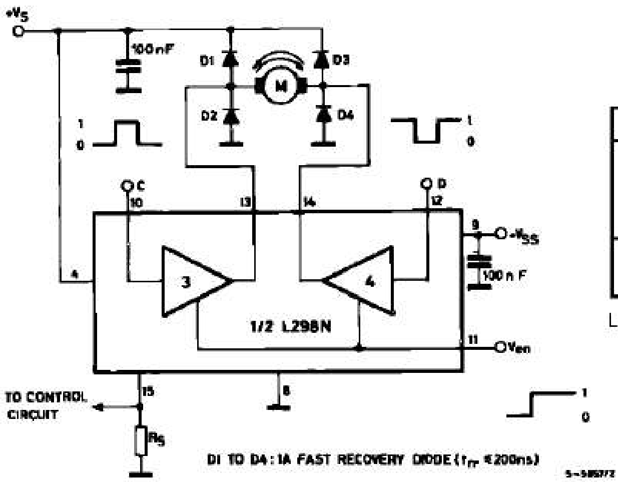


Figure 4.3.3 Transistor Driven H-Bridge (Brown 1998)

These transistor circuits are relatively expensive to build with an average circuit costing approximately sixty dollars for the components alone. However the advantage of these circuits is that they can be easily adapted to suit a variety of different voltage and power levels just by changing a few components. Therefore a transistor driven H-bridge is well suited to this project due to its adaptability and availability.

4.3.2 Commercial Packages

There are a few commercial H-bridge packages on the market today, the most common being the L298 Full-Bridge Driver made by ST Microelectronics (See Appendix C for data sheet). The L298 chip contains 2 H-bridges and can handle currents of approximately 1 amp and a peak current of about 3 amps (Brown 1998). Below is the typical configuration of the L298 used to as a H-bridge.



Inputs		Function
V_{en} = H	C = H ; D = L	Forward
	C = L ; D = H	Reverse
	C = D	Fast Motor Stop
V_{en} = L	C = X ; D = X	Free Running Motor Stop

L = Low H = High X = Don't care

Figure 4.3.4 Sample L298 Configuration (ST Electronics)

This package is relatively cheap costing around thirty dollars and can implemented easily into many circuits. The disadvantages with integrated circuits however is that they are only designed for set voltage and power values and that if they are damaged the whole circuit must be replaced. Therefore this package is not that well suited to the design of the deterrent device at this prototyping stage because it not very adaptable. This circuit will however be useful in the later stages of design when motor sizes and voltage values are fixed due to its high reliability.

4.4 Motor Selection

4.4.1 Stepper Motors

Permanent Magnet stepper motors incorporate a permanent magnet rotor, coil windings and magnetically conductive stators (Haydon Switch and Instrument Motors). They are called stepper motors because their rotation is induced by turning on different electromagnets in steps as shown in the figure below.

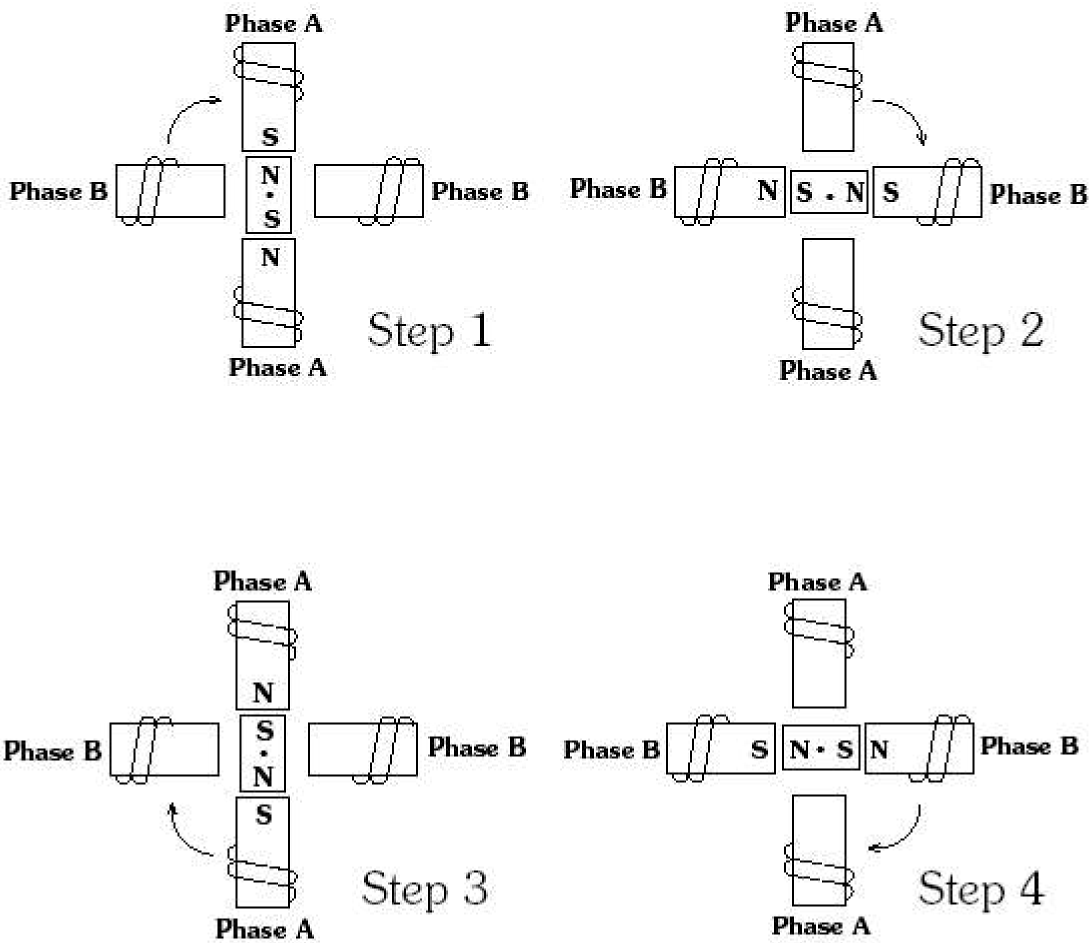


Figure 4.4.1 Stepper Motor Full Steps (Haydon Website)

In Step 1 the phase A electromagnet is turned on. This magnetically locks the rotor in the position due the attraction of the opposite poles. In Step 2 phase A is turned off and phase B is turned on, rotating the rotor by 90°. This process of turning on and off the phases is repeated at an increasing speed to a stage where the motor is spinning at a constant velocity. This method of stepping is very coarse and requires a significant time to build up speed. To improve this, half stepping can be used. Half stepping is achieved by turning on two phases at the same time. By doing this the rotor is locked between the two phases rotating only 45^0 instead of the full 90^0 step. The disadvantage of half stepping is that there is a 15-30% less torque than full stepping due to the smaller electromagnetic force (Haydon Switch and Instrument Motors).

Stepper motors are useful in a variety of different situations with the ability to produce adequate amounts of torque and a fairly accurate amount of rotation. They also however, can easily miss steps and are rigid in movement which can create problems when trying to gain position feedback. Therefore stepper motors are not suited to the deterrent device in this project which requires smooth continual movement.

4.4.2 DC Motors

Typical DC (Direct Current) motors operate in a similar way to stepper motors which is why the are often classified DC motors. A DC motor generates torque by creating an interaction between a fixed and rotating magnet field. The fixed field is supplied by high energy permanent magnets. The rotating field is created by passing a DC current through several different windings on the armature (rotating part) and timing which winding is powered through a device called a commutator. Power is applied to the armature by brushes which ride on the commutator (2002 Schreyer). An example of the inner workings of a typical motor can be seen in Figure 4.4.2 below.

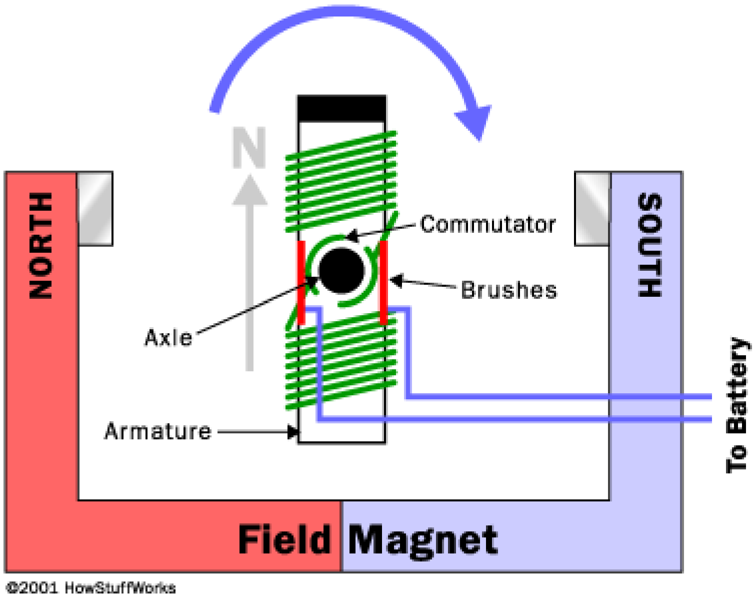


Figure 4.4.2 DC Motor (Howstuffworks Website)

DC motors have varying properties which depend on the size and the power of each motor. They differ to stepper motors because they do not require time to build up speed and can easily reach a constant velocity without missing steps or losing accuracy. The shortfall with DC motors is that they require a potentiometer to determine position or amount of rotation which adds costs to the overall system. Despite this fact DC motors have been selected for use in this project due to their ability to maintain a constant smooth flow of velocity to the system and because position feedback is not needed at this stage in design.

For this project the maximum voltage rating of 12V was selected in order to increase the portability of the device. Small 3-12V motors were selected for the device due to their availability to fit the gear housing (See Section 4.6.2 for more details) and price.

4.5 Electrical Schematic

The diagram below is a general overview of the connections and components of the deterrent system. The diagram shows the two H-bridges that control the movement of the system in their final configuration with the addition of the limit switches which are connected all connected to the parallel port.

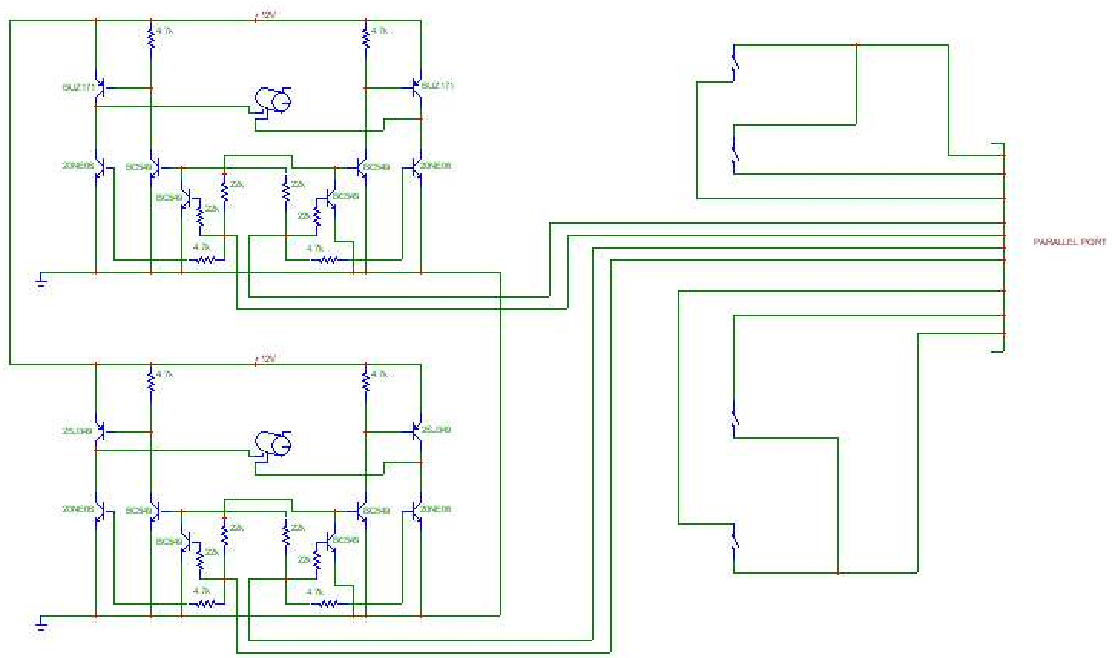


Figure 4.5.1 Overall Electrical Schematic

In this configuration the system uses all 8 data lines of the parallel port and several of the ground lines. As discussed in section 4.3, the H-bridges receive a TTL signal from the parallel port which controls the direction of rotation and powers the motor with the 12V supply rail. The configuration of the H-bridges was subject to the availability of parts and therefore caused the differences amongst the 2 bridges. A more detailed view of the final H-bridge configuration can be seen in Figure 4.5.2 on the next page.

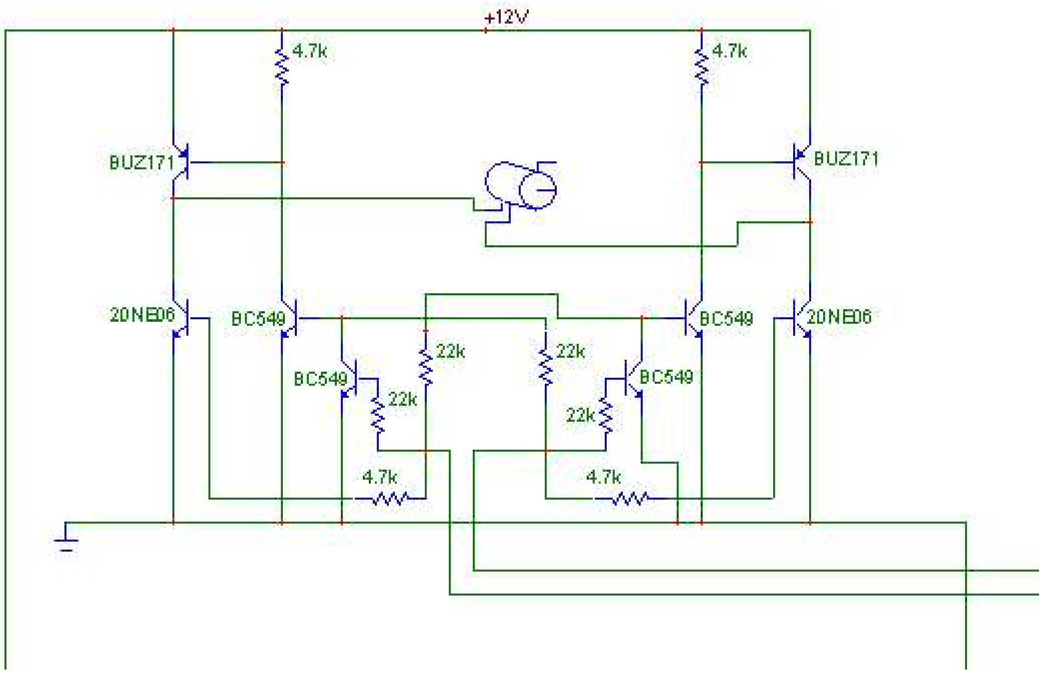


Figure 4.5.2 H-Bridge Detailed Design

The limit switches are powered by the parallel port are return a TTL signal to a data line when a limit is reached. The switches are powered by always outputting a 5V logic high from lines in the port to which both switches for each axis is connected (See Figure 4.5.3 below).

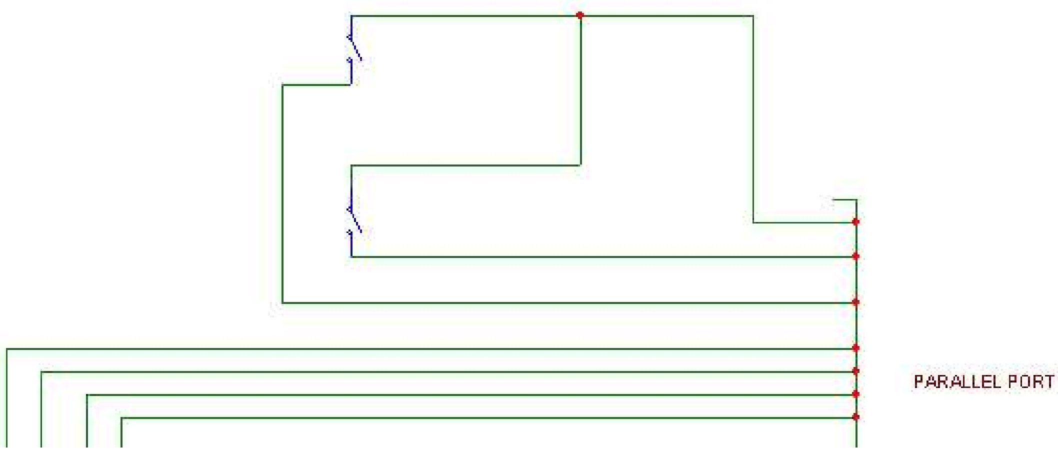


Figure 4.5.3 Limit Switch Connection

4.6 Final Design and Construction

Once all of the initial systems and components of the design had been selected, the next stage was to determine how to interface the components to obtain a fully functioning prototype and a method of construction. At this stage of development the most effective design process was actually building the prototype and testing the theory in order to verify the design. Therefore the first step in the construction of the prototype was sizing and preparing the MDF base for the configuration of the rest of the design.

4.6.1 Base

A 1200 x 450 mm section of MDF with a thickness of 12mm was selected for use as the base of the deterrent. The section was then cut to a 500 x 450 mm rectangle to increase the mobility of the system and to create sections that could be used later in the construction of the uprights (See Section 4.6.3). A 10mm hole was then drilled slightly off centre of the base (See Appendix D) in which the central axis of the deterrent will exist. The bottom disc is then used with a bolt to locate the position of the motors and gears with respect to the disc so that motor mounting holes can be drilled. Once this is complete two 3 mm holes are drilled for each motor which are 180 degrees apart. Adhesive feet were then also added to the corners of the base in order to reduce rocking during operation and to provide a flat surface. Once the construction on the base was complete the next stage was determining the method of driving the rotational base through gearing.

4.6.2 Gearing

The selection of gearing for the prototype was very limited because of its small size. Therefore the type of gearing selected was a universal gearbox and ladder chain and sprocket set made by a Tamiya which is leading manufacturer in toy and hobby equipment. These mechanical components were chosen because they were readily available and because they were a tenth of the price of the nearest competitor. A diagram of the universal gearbox can be seen in Figure 4.6.1 below.

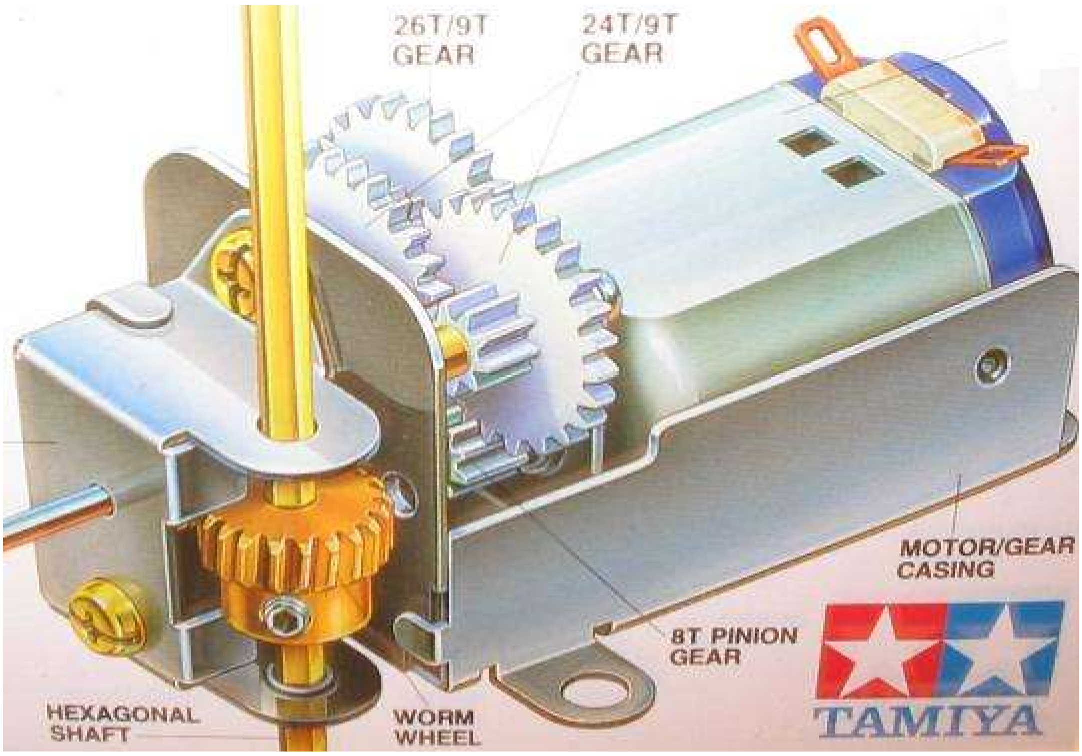


Figure 4.6.1 Tamiya Universal Gearbox (Tamiya, Inc.)

This gearbox was then coupled to the rotating base by attaching a sprocket to the hexagonal shaft, and attaching a chain to the disc to have a rack and pinion type configuration (See Figure 4.6.2 on following page).

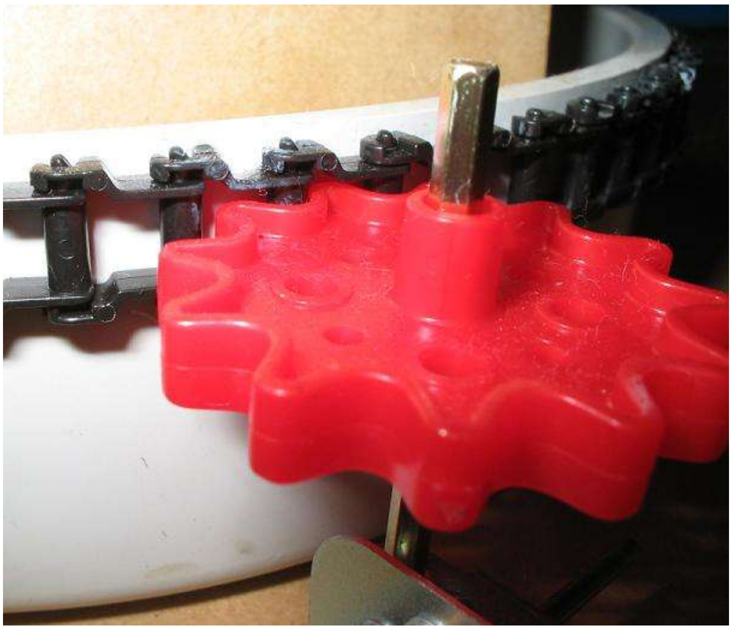


Figure 4.6.2 Gear and Chain Configuration

The gear in the above figure has an interference fit with the shaft to prevent slipping and the chain is attached to the rotating base with glue. Initially the design only specified one motor to control the movement of the disc however through limited testing another was added to reduce the amount of torque required by the motors and also to increase the stability of the rotation.

The movement and tilt of the camera is also controlled by a universal gearbox which is bolted to one of the uprights and has the camera mount fixed to the hexagonal shaft. All of the universal gearboxes are configured in their high speed setting of 101:1 to achieve the fastest response possible.

4.6.3 Disc

The disc or rotating base is the combination of the two vertical uprights and the disc on which the systems rotates. The uprights are made out of the cut off section of the MDF used for the base and are 250 x 120 mm in size. Each upright also has a 5 mm diameter hole centred 60 mm from the top of the section where the shaft is located. The base is a 150 mm diameter PVC end cap that is commonly used for hydraulic applications which was selected because of its low cost and shape (See Figure 4.6.3 below).

Figure 4.6.3 Disc Construction

The uprights in the above figure are fixed to the end cap by flat-head self tapping screws which provides strength whilst maintaining a smooth bottom surface in which to rotate upon.

4.6.4 Camera Mount

The camera mount is the member that connects the camera to the shaft of the gearbox. It is constructed out of the remaining MDF from the base, and is attached to the output shaft using an interference fit. The mount is a 30 x 30 mm square which has been designed to fit the Logitech camera selected in the Section 3.4. The Logitech camera fits into the 8 mm hole and is fixed in place by adhesive in order to increase stability. The camera mount at this stage of development was only designed to fit the camera and will need to be modified to include a deterrent. A picture of the camera fitted to the mount can be seen in Figure 4.6.4 below.

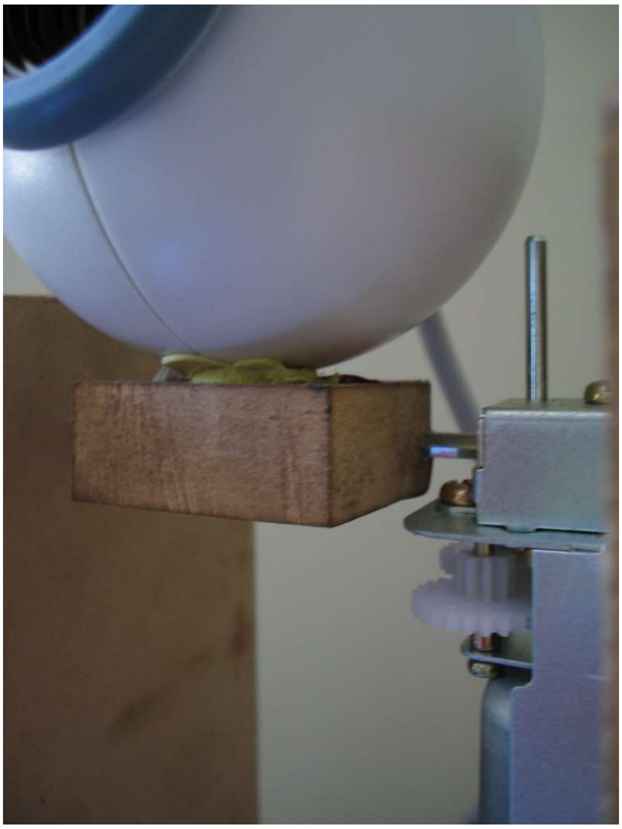


Figure 4.6.4 Camera Mount

4.6.5 Electrical Circuits

The electrical circuits for the system are configured as specified in Section 4.5 with each H-bridge having different families of transistors due to the availability of components. Each H-bridge circuit was constructed on small 80 x 60 mm bread boards which were selected to increase the adaptability of the system and increase the speed in which the circuits could be constructed (See Figure 4.6.5 below). After the construction of the circuits and testing was completed, the H-bridge circuits were then attached to the base and an upright using silicon which is used to guard against electrical interference and moisture.

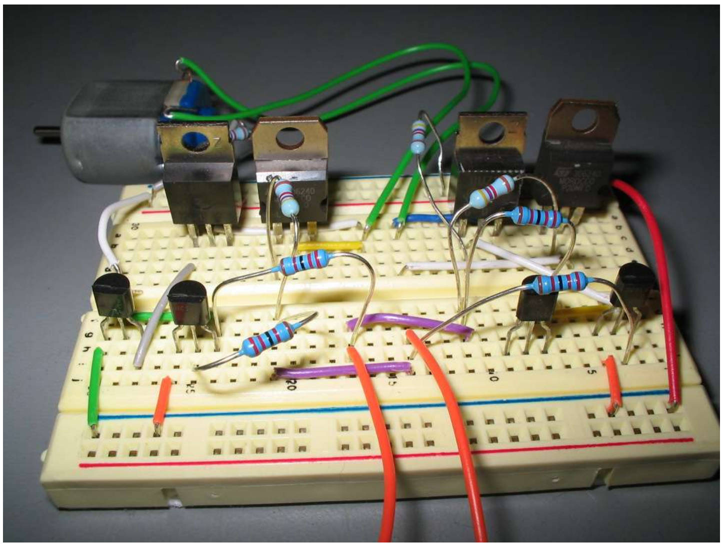


Figure 4.6.5 Bread Board Circuit

The remaining circuit containing the limit switches is soldered to the parallel port using a 60/40 rosin core solder. The limit switches are attached to the base and to an upright by high strength adhesive and are set from impact with an external switching member that is attached to the disc and the shaft for the upper motor.

4.6.6 Final Design Overview

Once the prototype was fully constructed, implementation problems had become obvious. The first major problem that arose in the construction was the amount of friction between the disc and the base. Even though the surfaces were relatively smooth and flat head screws had been used, there was still a large amount of friction to overcome for the system to rotate smoothly. Various attempts with washers and bearings were trialled, however the final solution was to introduce a second motor and gearbox as mentioned in Section 4.6.2 which improved both the speed and the stability of the system.

Another problem was the the fit of the hexagonal shaft with the camera mount. Initially the fit was rigid, however after limited use the shaft had came loose. To correct this, a small end plate used for models was screwed to the side of the camera mount and then fixed to the shaft using a grub screw to minimise slipping.

The final problem with the prototype was the H-bridges. Both circuits reacted similarly to the tests with both operating correctly 90% of the time when the drive signal came from a battery, however having no reaction or a very delayed reaction to TTL signals from a computer. This fact was most likely related to Windows XP issues however both H-bridges operated quicker in one direction which also speculates that the problem could rely in the transistor packages or the circuit configuration. A detailed investigation is needed to solve this problem which will be discussed in Section 6.3.

Chapter 5

Software Design

5.1 Requirements and Specifications

The minimum requirement of the software for this prototype, is a program that can detect movement and control the motors to react in the appropriate way to the movement. The software needs also to be able to run on a standard desktop or laptop PC with the ability to output TTL signals via the parallel port and receive images from a web cam. Additional requirements such as the ability to preview the image, and the ability to run a user controlled mechanical test are other important functions which must be included in the code.

Due to the adaptable nature of the prototype, the source code for the control software must be kept modular in order to increase the number of applications that it can be used for and to increase the speed in which it can be updated. Therefore the code used for this project must be kept fairly simple so that it can be easily read and updated by users of differing skill levels.

5.2 Programming Language Selection

The initial programming language selected for this project was Microsoft Visual C++ because of its power, support, and ability to create stand alone executable files. However after an initial investigation into the language, Visual C++ was found very complex and require additional packages such as the Direct X 9 software development kit to perform image processing. Therefore Visual Basic was selected as the programming language because of its simple nature and close relationship to Quick Basic. This language was also chosen because of the existence of software written by E.J. Bantz Jr. and Professor John Billingsley that related to image acquisition using a web cam.

5.3 Program Flow Chart

At the beginning of the design phase the following flow chart was created in order to plan the operation of the software and to divide the program into modules for increased implementation speeds and debugging. Each section of the chart represents a portion of the final program in either the form of an algorithm or a function. The flow chart represents the concepts of the final software and shows each the possibilities during normal operation. In the case of this program there are different modes that are used for mechanical testing and image previewing which are represented by the different paths from the start window. In Section 5.6 each of the blocks and operations in the chart will be covered in more detail with pseudo code which describes more accurately their method of operation.

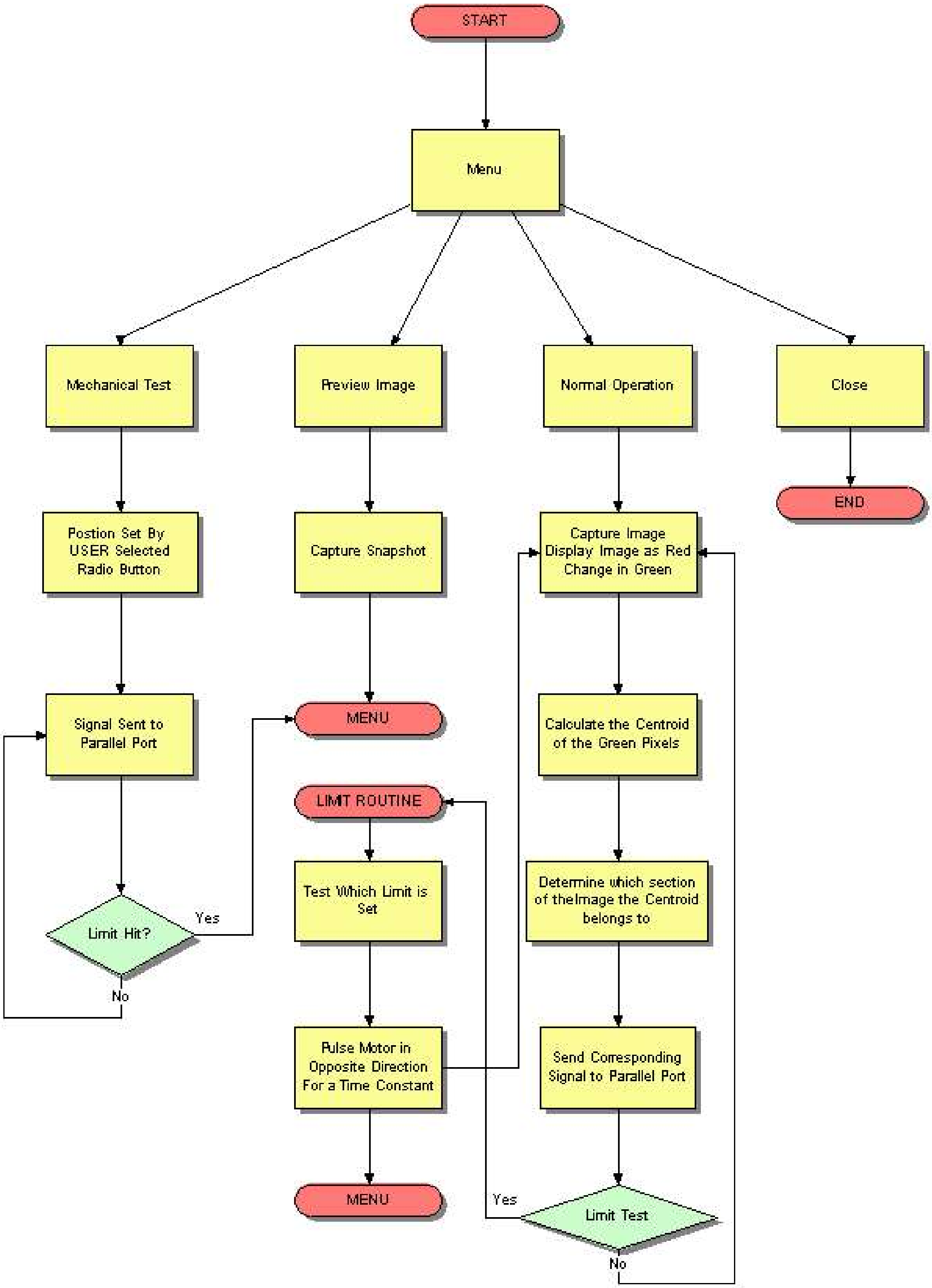


Figure 5.3.1 Program Flow Chart

5.4 Image Analysis

The method of image analysis used in this software is similar to the methods mentioned in Section 3.2 with image comparison being the major technique used. The existing software written by E.J. Bantz Jr. and Professor John Billingsley accepts the images from the web cam and stores the pixel values into arrays in the form below.

```
w = Squiz.pwidth
h = Squiz.pheight
Debug.Print w, h
ReDim picbytes(2, w - 1, h - 1) As Byte

Do
        Debug.Print "STA call "; stoppit
         Squiz.SnapToArray picbytes()
        Debug.Print "STA return"; stoppit
         i = DoEvents
         For j = 0 To h - 1
                 For i = 0 To w - 1
                         p = picbytes(2, i, j)
                         q = picbytes(1, i, j)
                         r = picbytes(0, i, j)

    Pic.PSet (i, h - j), RGB(p, q, r)
```

Using this framework the above code has been modified to display images only in red and to only display every second pixel to increase program speed and to combat overflow errors. After the code transforms the image into a red grey scale image it then compares each pixel value to its previous to determine where movement has occurred. If the change in pixel value is above a calculated threshold the pixel displayed in that position then becomes green to contrast with the current image. This method is used to provide an obvious detection of movement and can be adjusted to suit small or large amounts of movement. A demonstration can be seen in Figure 5.4.1 on the following page.

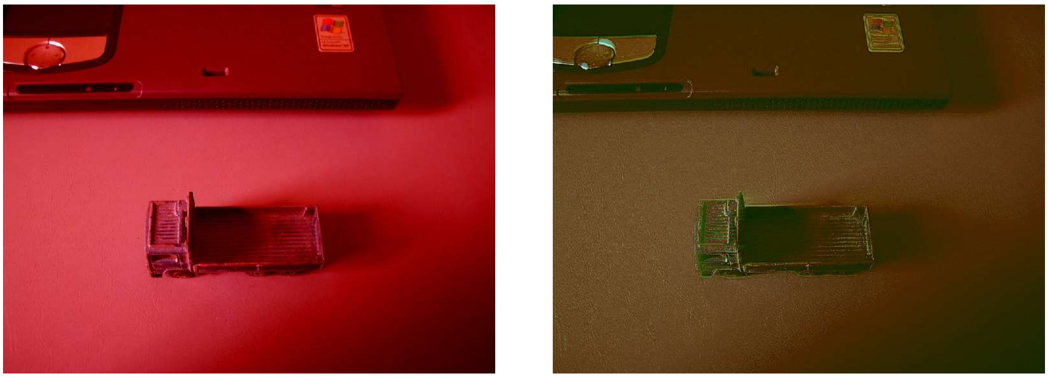


Figure 5.4.1 Image Comparison

Once the difference between the images is displayed the centre of the movement is then calculated from the green pixels using the following formula.

$$\text{Centre of Movement} = \frac{\sum i}{(No.\ of\ Pixels)} i\,,\ \frac{\sum j}{(No.\ of\ Pixels)} j = Average\ of\ Movement$$

From this equation the centre of movement is given as a pixel location which is then located with reference to a square grid of nine equal sections. Each section of this grid relates to the movement of the deterrent system with the top left section equalling a rotation by the base to the left and a positive rotation of the camera.

At this stage of the design process edge detection has not been used, however it will be required before the strobe light has been attached to the system. The inclusion of edge detection to this system is desired in future versions of this software because it will reduce processing times significantly and increase the accuracy of the program.

5.5 Graphical User Interface

When designing a graphical user interface (GUI) for a prototyped system many considerations must be taken into account. The GUI must contain a significant amount of important information whilst being simplistic, intuitive and easy to read. To achieve this the GUI was designed around the following three principles or primary human factors.

5.5.1 Visual Acuity

Visual acuity is the ability of the eye to focus on small areas. The retina of eye can only focus on about on a very small portion of a computer screen, or anything for that matter, at any one time (Jansen, 1998). At a distance greater than 2.5 degrees from the point of focus, visual sharpness decreases by half, therefore a circle of radius 2.5 degrees around the point is the maximum area a user can see clearly.

In reference to GUI the standard rule is that from a normal viewing distance of 50 cm, 5 degrees translates into about 4.25 cm circle. On a standard screen, 4.25 cm is an area about 14 characters wide and about 7 lines high. This is the amount of information that a user can take in at any one time, and it limits the effective size of icons, menus, dialogs boxes, etc. (Jansen, 1998). Any object or control that is larger than the size of the visual acuity circle causes users to constantly be moving their eyes to keep focus which leads to eye strain and tiredness over a period of time.

5.5.2 Gestalt Principle

The Gestalt Principle states that people use a top-down approach to organizing data and attempts to identify criteria that cause people to group certain items together in a display. For example, if the user knows where one item in a group is on a screen, he or she will expect other like items to be there also (Jansen, 1998). This grouping of similar information helps to improve the speed of operations of the user and minimises errors.

5.5.3 Information Presentation

Currently the amount of information present is the most basic of GUI design considerations and has shown that making screens less crowded improves screen clarity and readability. Therefore most modern GUI only present information that is relevant to the current operation. Empirical researchers show that limiting the information to that necessary for the user reduces errors and time to perform tasks. Errors and performance time increase as the GUI presents more information (Jansen, 1998).

The use of colour can also improve the effectiveness of a GUI due to its ability to relay important information without requiring the user to focus on that area specifically. Colours such as red for stop buttons and green for go buttons help to improve the speed in which the user can recognise controls because of their use in everyday life. However the over use of colour can have adverse effects on a user creating confusion and over stimulation.

5.5.4 GUI Features

Figure 5.5.1 is a screen shot of the final design of the GUI. It conforms to the previously mentioned qualities of good GUI design by containing all the information needed by the user.

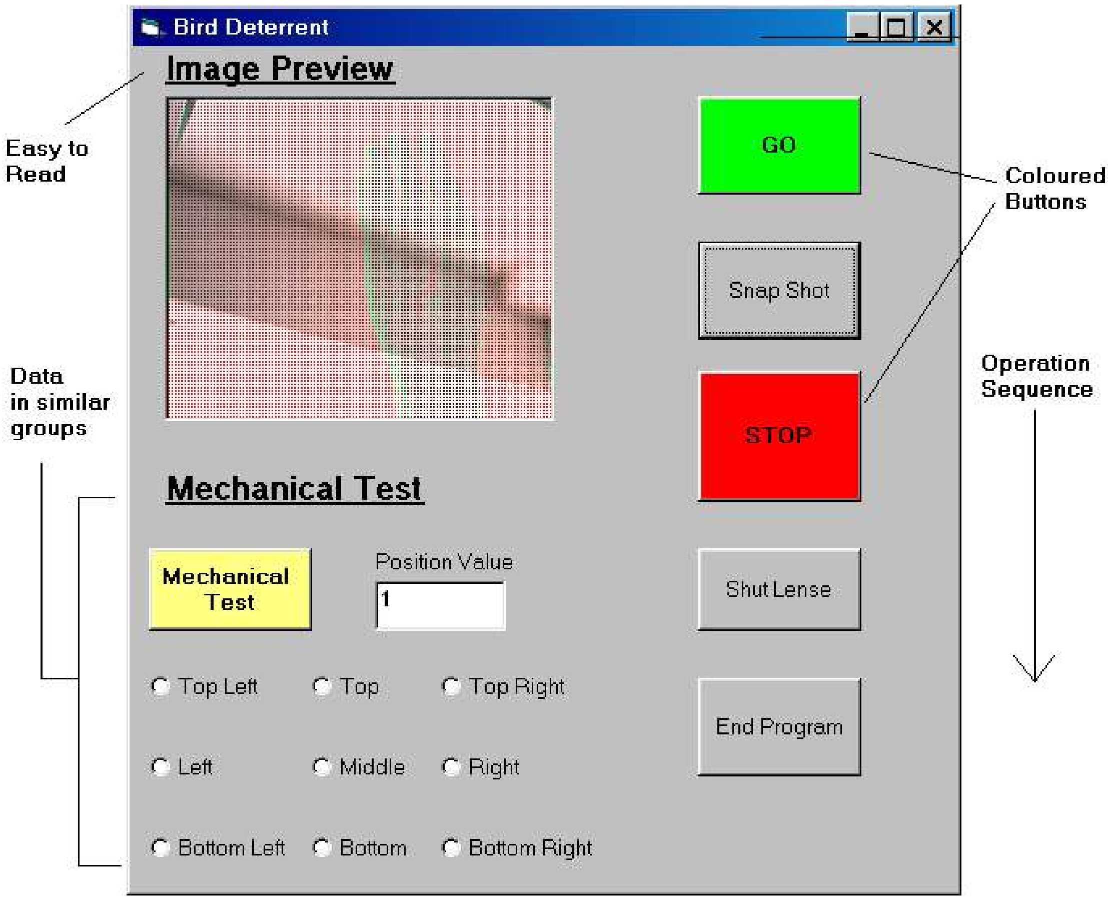


Figure 5.5.1 GUI Design

The above GUI represents the layout of the final system, however it is not complete in function. The remaining components of this limitations in this program are discussed later in section 6.4.

5.6 System Overview

This section contains a listing of the algorithms used in the control software for the prototype. The listing below is written in pseudo code to improve the readability of the program and to be in a format that can easily be changed to different programming languages. It is written in three sections, the mechanical test routine, the limit testing routine, and the general operation routine which calls the limit routine. A listing of the final developed code for this project is located in Appendix B and differs slightly to the pseudo code. The difference between these to listings and the problems encountered during programming can be found in Section 6.4.

5.6.1 Mechanical Test Routine

Mechanical Test

```
OnClickedMechTButton()
IN Port = Limits
WHILE Limits = 0
        {

OnClickedRadioButton()

Switch (Pos)
{
        case'1': OUT Port 00001010          //Top Left
        case'2': OUT Port 00000010          // Left
        case'3': OUT Port 00000110          //Bottom Left
        case'4': OUT Port 00001000          //Top
        case'5': OUT Port 00000000          //Centre
        case'6': OUT Port 00000100          //Bottom
        case'7': OUT Port 00001001          //Top Right
        case'8': OUT Port 00000001          //Right
        case'9': OUT Port 00000101          //Bottom Right
}
        }
Run LIMRT
```

5.6.2 Limit Test Routine

```
LIMIT ROUTINE (LIMRT)

IN Port = Limits

While t > 0
{
Switch(Limits)
{
        case'00010000': OUT Port 00000001
        case'00100000': OUT Port 00000010
        case'01000000': OUT Port 00001000
        case'10000000': OUT Port 00000100
}
t = t-1         //Time Constant
}
Return
```

5.6.3 General Operation

```
General Operations

DO
{
        FOR j = 0 to height-1
                FOR i = 0 to width - 1
                p = picbytes(2, i, j)
                q = picbytes(1, i, j)

        IF q1 = q
        {
        Plot Red
        }
        ELSE
        {
        Plot Green
        x = i
        y = j
        S = S + x
        B = B + y
        }
        RUN LIMRT

        }
    }
```

```
(S)/Last x = U
(B)/Last y = V

Switch
    {
        case U> 0.6* W & V > 0.6*H: OUT Port 00001010
        case U> 0.6* W & V < 0.6*H & V> 0.3*H: OUT Port 00000010
        case U> 0.6* W & V < 0.3*H: OUT Port 00000110
        case U> 0.6* W & V > 0.6*H: OUT Port 00001010
        case U> 0.3* W & U < 0.6*W & V> 0.6*H: OUT Port 00001000
        case U> 0.3* W & U < 0.6*W & V< 0.6*H& V>0.3*H: OUT
        Port $00
        case U> 0.3* W & U < 0.6*W & V< 0.3*H: OUT Port 00000100
        case U< 0.3* W & V > 0.6*H: OUT Port 00001001
        case U< 0.3* W & V < 0.6*H & V> 0.3*H: OUT Port 00000001
        case U> 0.3* W & V < 0.3*H: OUT Port 00001000

q1 = q

Loop Until CancelClick()
```

Chapter 6

Improvements and Further Work

6.1 Introduction

During the implementation phase of this deterrent system many obstacles and design flaws became more apparent as the system was constructed. This section discusses the limitations of the initial system which were already known and suggests possible ways in which the initial system can be improved. Included also in this chapter is an analysis of the final mechanical, electrical and software design for this system which examines each of the areas effectiveness and attempts to offer improvements and solutions to problems that arose. Once each section of the constructed system has been analysed, the attachment and implementation of the selected deterrent device and the format and procedure for testing is then discussed. The final section in this chapter contains suggestions for further work on this project and outlines what needs to be completed to turn this prototype into a commercially available bird deterrent product.

6.2 Mechanical Design

As mentioned in Section 4.6.6, the final constructed prototype differed from the original design in may areas due to unforeseen problems and unpredicted behaviour. In this section the final resulting mechanical system will be assessed in relation to its effectiveness and from these results improvements will be suggested.

6.2.1 Base Rotation

After several more limited tests of the system, the rotating base was still found 'wobble' during normal rotation. The overall stability rotation had been earlier improved by the addition of a second motor and gearbox, however there still exists a 1 to 5 mm travel between the base and the disc. From close inspection the most likely reason for the 'wobble' is due to poor manufacturing with items such as the driven chain not being a constant height and the centre of mass of the rotating components not being aligned with the rotation axis. These problems can be easily corrected once the device is fully tested and manufactured so therefore are not of large concern. Other possible reasons for the poor rotation performance could be simply the fact that the disc only contacts the base at a single point which greatly decreases its stability. Therefore to solve this problem a redesign of the base/disc connection is needed to made with the disc having at least 4 points that are in contact with the base during rotation (See Figure 6.2.1 on the following page).

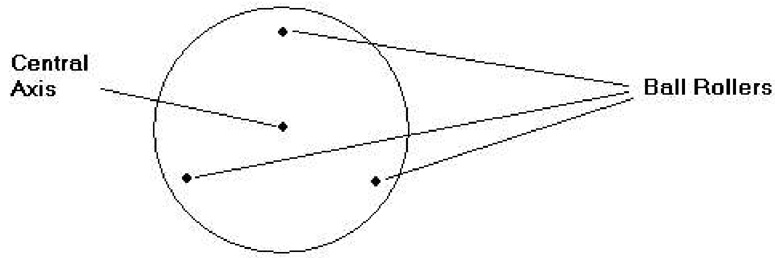


Figure 6.2.1 Re-Designed Base

During the initial design phase and after some limited tests a second motor was selected to help control the rotation of the base. However after further testing the second motor was found to more of a hindrance rather than a help to the first motor. Due to slight differences in speed the first motor was slowed by the second because it had to take the initial load combined with the 101:1 gearbox to spin the base. Therefore the in the final constructed prototype only one motor and the second gearbox were used for rotation which was found to be sufficient.

6.2.2 Limits and Feedback

The limit switches were effective in determining when a limit was reached however greatly decreased the range and area covered by the deterrent. They also were only designed to correct the axis in which the limit was set which could in some cases have the camera always only scanning an area which contains no activity making the system stop. To overcome these shortfalls the addition of position feedback is necessary to later versions of this system. The presence of position feedback could be used to create a more dynamic system that does not rely on limits and that could correct both rotations at the same time. Other benefits that come with position feedback is the ability to calculate and change the speed of the system and its response to situations.

To implement a form a position feedback the system would need to be revised in order to make room for items such as a rotatory encoder and its connections. With this in place with the addition of contacts the system would then have the ability to rotate 360 degrees greatly increasing its effectiveness. Therefore it is suggested that position feedback be included in the revised design of this system.

6.3 Electrical Design

The most significant problem with the electrical component of the system was the intermittent operation of the H-bridges. On both constructed circuits the controlled motor only operated correctly in one direction with little drive in the opposite direction. Initially this was thought to be a construction problem however after extensive analysis there was no fault in the circuit.

An additional problem that occurred with the H-bridges was their response to TTL levels. On several tests the H-bridge responded well when the control signal was supplied by a battery, however had a delayed or minute reaction when the signal was supplied by a computer. More testing with different computers resulted in the delayed reaction being found to be caused by the Windows XP operating system. Once this had been determined the TTL control levels controlled that direction had designed.

Due to the problems encountered, a redesign of the electrical system is needed for the deterrent system to operate correctly. The L298 package (Appendix C) is recommended to replace the transistor driven H-bridges because it can provide predictable results, and one chip can be used to drive a single motor. This package would greatly increase the reliability of the system and reduce the cost and time in development. The updated design of the electrical system would also need to specify that the control computer does runs an older version of windows or a Linux operating system.

6.4 Software Design

The final program for the control of the deterrent system remains incomplete with the limit routine and the mechanical test functions still to be written. These functions were not and cannot be written until the system hardware is fully functional because they require both inputs and outputs from the computer system. Pseudo code for these functions has been written and is listed in section 5.6 for use in future work. This stage of implementation is the final step before the total system tested.

The main operating program (See Appendix B) runs without error although has not been throughly tested. Testing opportunities were limited due to limited time and the absence of the win95io.dll file that is necessary for operation. Therefore further testing and improvement of this program is required for the software to be reliable and accurate.

During programming the computer used was found to unreliable with critical software errors occurring every hour. The visual basic software was also limited the capability of the software by being slow to handle large numbers and lots of pixel information.

Ideally for future additions to the software a faster computer is needed due to the large amount of data that is required in streaming video. Other additional hardware such as a frame grabber card would be a useful increasing the speed of the program by reducing the amount of information that needs to be processed by the software.

As mentioned in section 5.2, Visual C ++ was originally selected as the programming language for this system. It is a more powerful language than Visual Basic and can handle large amounts of data with ease. Therefore for future additions to this project it is suggested that the code be converted from Visual Basic to Visual C++ to improve the overall operation of the system.

Other additions such as edge detection and previously mentioned analysis methods would help to improve the accuracy and reliability of the system and therefor should be considered during re-design. With these necessary changes the control software will be fast and accurate enough to be effective in deterring birds.

6.5 Deterrent Application and Testing

Currently there exists no standard for bird deterrent testing which allows many inadequate products to enter the market place. Due to the non-existence of a standard the following test procedure is tailored to measure the performance of this designed deterrent system.

To begin with, each section of the deterrent must be tested in order to verify that each component operates correctly. The order the sections must be tested in is listed below:

1. Mechanical
2. Electrical
3. Software
4. Deterrent
5. Overall System

The suggested test procedures for the deterrent system are listed below. These procedure were developed during implementation and list the necessary steps to ensure correct operation.

Mechanical Test Procedure

1. Ensure that all levers make contact with limit switches
2. Ensure all fixtures are secured
3. Rotate base with gears unattached and check for stability
4. Check that both shafts rotate
5. Check that both motors operate correctly and can drive load.

Electrical Test Procedure

1. Ensure all circuits are configured as per design
2. Test each H-bridge for correct operation and identical speeds in both directions
3. Test all limit switches
4. Run a trial operation of the system using a battery to supply TTL levels to the H-bridge.
5. Check the parallel port connection for correct pins and any losses

Software Test Procedures

1. Run the Limit routine and activate switch by hand, checking I/O levels.
2. Run mechanical test routine using the radio buttons to control movement and configure the time constant for the limit routine
3. Test web cam image by previewing image and running a dummy program
4. Test Overall program by checking that the system responds to corresponding movement.
5. Measure the speed of the system and adjust to suit.

Deterrent Test Procedure

1. Ensure that the deterrent device is fixed securely and operates correctly.
2. Test the system to see that all components especially the software still operate correctly.
3. Conduct tests in laboratory to determine the range and speed of movement.
4. Conduct initial tests on a single bird in an enclosed area to determine the safety of the system and its effectiveness

Overall Test Procedure

1. Obtain permission to conduct limited tests in a large bird avery
2. Study a the habits of birds at a particular location before, during and after the introduction of the deterrent device.
3. Analyse results and modify the system or method of use accordingly.

These steps are designed to outline what needs to be done to finish the development of this bird deterrent device. They cover all aspects of operation and list the necessary steps to be taken during initial and final testing. Once these procedures are complete the findings of the tests can then be published with then the opportunity to commercialise the product.

6.6 Further Project Work

This project sets a foundation that could be easily taken up as a future project. It covers the design process of the deterrent system and describes the problems encountered during implementation. Later sections suggest possible solutions to each of the problems and make recommendations for future improvements. A future project topic could be to conduct a design analysis of the system and to fully construct and test the redesign system.

Due to the adaptability of this system many other applications can stem from the design into areas such as security and other forms of tracking. This system is modular in design and can be easily changed to suit almost any application. Another possible project topic that could include sections of this design would be a camera based tracking system used to follow the movements of students in computer rooms (similar to the case study in section 3.3.2).

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ment.html

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http://www.bird-x.com/

http://www.ctips.com/spp.html#2 "Parallel Port"

Appendix A

Project Specification

University of Southern Queensland

FACULTY OF ENGINEERING AND SURVEYING

ENG 4111/4112 Research Project
PROJECT SPECIFICATION

FOR: TIM CLARKE

TOPIC: Automated Bird Deterrent System

SUPERVISOR: Chris Snook

PROJECT AIM: This project aims to provide an automated device/system that utilises machine vision to track and deter birds from roosting around or on buildings.

PROGRAMME: **Issue B, 18th October 2004**

1. Conduct a comprehensive literature review of current bird deterrent technologies.

2. Conduct a design analysis of each of the current systems in the field and evaluate each of these with respect to the proposed deterrent system.

3. Conduct a limited review of machine vision and image recognition.

4. Design mechanical section of proposed bird deterrent system.

5. Design electrical section of proposed bird deterrent system.

6. Design software for analysis and recognition.

7. Construct integrated prototype system and evaluate in limited tests

AGREED: Tim Clarke (Student) ____________ (Supervisor)

18/10/04

Appendix B

Software Listing

B.1 General Program

```
Option Explicit
Dim stoppit As Boolean
Dim n As Integer
'Dim picbytes() As Byte
Dim w As Integer, h As Integer



Private Sub Endit_Click()
End
End Sub

Private Sub Form_Load()
Show
Squiz.Source
Squiz.Format
Squiz.OnTop

End Sub

Private Sub quit_Click()
stoppit = True
End Sub

Private Sub Runnit_Click()
Runnit.Enabled = False
Dim i As Integer, j As Integer, p As Integer
Dim q As Integer, r As Integer, q1 As Integer
Dim S As Long, B As Long
Dim x As Integer, y As Integer
Dim U As Integer, V As Integer

w = Squiz.pwidth
h = Squiz.pheight
S = 1
B = 1
x = 1
y = 1
Debug.Print w, h
ReDim picbytes(2, w - 1, h - 1) As Byte
Do
'  Squiz.SnapToClipboard
'  Pic.Picture = Clipboard.GetData
'  n = n + 1
'  Debug.Print n
Debug.Print "STA call "; stoppit
  Squiz.SnapToArray picbytes()
Debug.Print "STA return"; stoppit
  i = DoEvents
  For j = 0 To h - 1 Step 4
    For i = 0 To w - 1 Step 4
```

```
      p = picbytes(2, i, j)
       q = picbytes(1, i, j)
       'r = picbytes(0, i, j)



    If q1 > Abs(1.15 * q) Then
        Pic.PSet (i, h - j), RGB(0, q, 0)
            x = i
            y = j
            S = S + x
            B = B + y


    Else
        Pic.PSet (i, h - j), RGB(p, 0, 0)
    End If


    q1 = q



    Next
  Next

U = 1 / (S / x)
V = 1 / (B / y)


Select Case U & V
            Case U > 0.6 * w & V > 0.6 * h: 'Out Port00001010
            Case U > 0.6 * w & V < 0.6 * h & V > 0.3 * h: ' Out Port 00000010
            Case U > 0.6 * w & V < 0.3 * h: 'Out Port  00000110
            Case U > 0.6 * w & V > 0.6 * h: 'Out Port 00001010
            Case U > 0.3 * w & U < 0.6 * w & V > 0.6 * h: 'Out Port $00
            Case U > 0.3 * w & U < 0.6 * w & V < 0.3 * h: 'Out Port 00000100
            Case U < 0.3 * w & V > 0.6 * h: ' Out Port 00001001
            Case U < 0.3 * w & V < 0.6 * h & V > 0.3 * h: 'Out Port 00000001
            Case U > 0.3 * w & V < 0.3 * h: 'Out Port 00001000
End Select



Loop Until stoppit
stoppit = False
Debug.Print "wait for stoppit again"
Do
  i = DoEvents
Loop Until stoppit
Debug.Print "Now shut eye"
Squiz.shut
stoppit = False
```

```
Do
  i = DoEvents
Loop Until stoppit
End
End Sub

Private Sub shut_Click()
Squiz.shut
End Sub

Private Sub Snap_Click()
Squiz.SnapToClipboard
Pic.Picture = Clipboard.GetData
End Sub
```

Appendix C

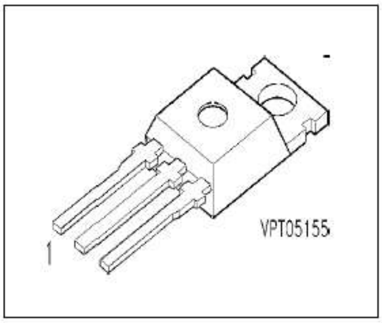
Component Data Sheets

C.1 BUZ171

SIEMENS **BUZ 171**

SIPMOS ® Power Transistor

- P channel
- Enhancement mode
- Avalanche rated



Pin 1	Pin 2	Pin 3
G	D	S

Type	V_{DS}	I_D	$R_{DS(on)}$	Package	Ordering Code
BUZ 171	-50 V	-8 A	0.3 Ω	TO-220 AB	C67078-S1450-A2

Maximum Ratings

Parameter	Symbol	Values	Unit
Continuous drain current T_C = 30 °C	I_D	 -8	A
Pulsed drain current T_C = 25 °C	I_{Dpuls}	 -32	
Avalanche energy, single pulse I_D = -8 A, V_{DD} = -25 V, R_{GS} = 25 Ω L = 1.1 mH, T_j = 25 °C	E_{AS}	 70	mJ
Gate source voltage	V_{GS}	± 20	V
Power dissipation T_C = 25 °C	P_{tot}	 40	W
Operating temperature	T_j	-55 ... + 150	°C
Storage temperature	T_{stg}	-55 ... + 150	
Thermal resistance, chip case	R_{thJC}	≤ 3.1	K/W
Thermal resistance, chip to ambient	R_{thJA}	≤ 75	
DIN humidity category, DIN 40 040		E	
IEC climatic category, DIN IEC 68-1		55 / 150 / 56	

C.2 2SJ349

TOSHIBA 2SJ349

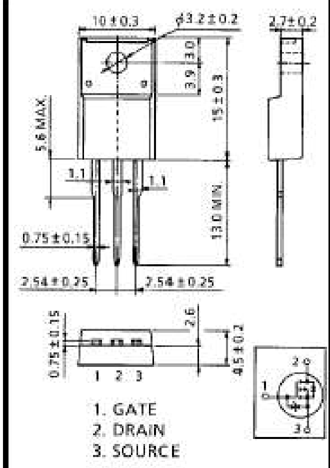
TOSHIBA Field Effect Transistor Silicon P Channel MOS Type (L^2−π−MOSV)

2SJ349

DC−DC Converter, Relay Drive and Motor Drive Applications

Unit: mm

- 4 V gate drive
- Low drain−source ON resistance : $R_{DS\ (ON)}$ = 33 mΩ (typ.)
- High forward transfer admittance : $|Y_{fs}|$ = 20 S (typ.)
- Low leakage current : I_{DSS} = −100 μA (max) (V_{DS} = −60 V)
- Enhancement−mode : V_{th} = −0.8~−2.0 V (V_{DS} = −10 V, I_D = −1 mA)



JEDEC	―
JEITA	SC-67
TOSHIBA	2-10R1B

Weight: 1.9 g (typ.)

Maximum Ratings (Ta = 25°C)

Characteristics		Symbol	Rating	Unit
Drain−source voltage		V_{DSS}	−60	V
Drain−gate voltage (R_{GS} = 20 kΩ)		V_{DGR}	−60	V
Gate−source voltage		V_{GSS}	±20	V
Drain current	DC (Note 1)	I_D	−20	A
	Pulse(Note 1)	I_{DP}	−80	A
Drain power dissipation (Tc = 25°C)		P_D	35	W
Single pulse avalanche energy (Note 2)		E_{AS}	800	mJ
Avalanche current		I_{AR}	−20	A
Repetitive avalanche energy (Note 3)		E_{AR}	3.5	mJ
Channel temperature		T_{ch}	150	°C
Storage temperature range		T_{stg}	−55~150	°C

Thermal Characteristics

Characteristics	Symbol	Max	Unit
Thermal resistance, channel to case	$R_{th\ (ch-c)}$	3.57	°C / W
Thermal resistance, channel to ambient	$R_{th\ (ch-a)}$	62.5	°C / W

Note 1: Please use devices on condition that the channel temperature is below 150°C.

Note 2: V_{DD} = −50 V, T_{ch} = 25°C (initial), L = 1.44 mH, R_G = 25 Ω, I_{AR} = −20 A

Note 3: Repetitive rating; Pulse width limited by maximum channel temperature.

This transistor is an electrostatic sensitive device.
Please handle with caution.

C.3 BC549

FAIRCHILD
SEMICONDUCTOR®

BC546/547/548/549/550

BC546/547/548/549/550

Switching and Applications

- High Voltage: BC546, V_{CEO}=65V
- Low Noise: BC549, BC550
- Complement to BC556 ... BC560

TO-92

1. Collector 2. Base 3. Emitter

NPN Epitaxial Silicon Transistor

Absolute Maximum Ratings T_a=25°C unless otherwise noted

Symbol	Parameter	Value	Units
V_{CBO}	Collector-Base Voltage : BC546 : BC547/550 : BC548/549	80 50 30	V V V
V_{CEO}	Collector-Emitter Voltage : BC546 : BC547/550 : BC548/549	65 45 30	V V V
V_{EBO}	Emitter-Base Voltage : BC546/547 : BC548/549/550	6 5	V V
I_C	Collector Current (DC)	100	mA
P_C	Collector Power Dissipation	500	mW
T_J	Junction Temperature	150	°C
T_{STG}	Storage Temperature	-65 ~ 150	°C

Electrical Characteristics T_a=25°C unless otherwise noted

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Units
I_{CBO}	Collector Cut-off Current	V_{CB}=30V, I_E=0			15	nA
h_{FE}	DC Current Gain	V_{CE}=5V, I_C=2mA	110		800	
V_{CE} (sat)	Collector-Emitter Saturation Voltage	I_C=10mA, I_B=0.5mA I_C=100mA, I_B=5mA		90 200	250 600	mV mV
V_{BE} (sat)	Base-Emitter Saturation Voltage	I_C=10mA, I_B=0.5mA I_C=100mA, I_B=5mA		700 900		mV mV
V_{BE} (on)	Base-Emitter On Voltage	V_{CE}=5V, I_C=2mA V_{CE}=5V, I_C=10mA	580	660	700 720	mV mV
f_T	Current Gain Bandwidth Product	V_{CE}=5V, I_C=10mA, f=100MHz		300		MHz
C_{ob}	Output Capacitance	V_{CB}=10V, I_E=0, f=1MHz		3.5	6	pF
C_{ib}	Input Capacitance	V_{EB}=0.5V, I_C=0, f=1MHz		9		pF
NF	Noise Figure : BC546/547/548 : BC549/550 : BC549 : BC550	V_{CE}=5V, I_C=200μA f=1KHz, R_G=2KΩ V_{CE}=5V, I_C=200μA R_G=2KΩ, f=30~15000MHz		2 1.2 1.4 1.4	10 4 4 3	dB dB dB dB

h_{FE} Classification

Classification	A	B	C
h_{FE}	110 ~ 220	200 ~ 450	420 ~ 800

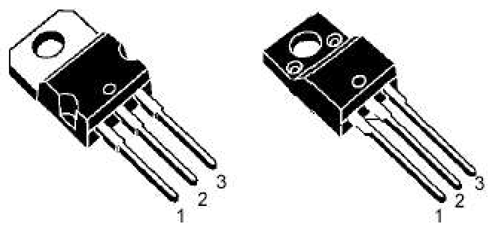
C.4 20NE06

STP20NE06L
STP20NE06LFP

N - CHANNEL 60V - 0.06 Ω - 20A TO-220/TO-220FP STripFET™ POWER MOSFET

TYPE	V_{DSS}	$R_{DS(on)}$	I_D
STP20NE06L	60 V	< 0.07 Ω	20 A
STP20NE06LFP	60 V	< 0.07 Ω	13 A

- TYPICAL $R_{DS(on)}$ = 0.06 Ω
- EXCEPTIONAL dv/dt CAPABILITY
- 100% AVALANCHE TESTED
- LOW GATE CHARGE 100 °C
- APPLICATION ORIENTED CHARACTERIZATION



TO-220 TO-220FP

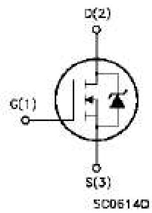
DESCRIPTION

This Power Mosfet is the latest development of STMicroelectronics unique " Single Feature Size™ " strip-based process. The resulting transistor shows extremely high packing density for low on-resistance, rugged avalance characteristics and less critical alignment steps therefore a remarkable manufacturing reproducibility.

APPLICATIONS

- DC MOTOR CONTROL
- DC-DC & DC-AC CONVERTERS
- SYNCHRONOUS RECTIFICATION

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value		Unit
		STP20NE06	STP20NE06FP	
V_{DS}	Drain-source Voltage (V_{GS} = 0)	60		V
V_{DGR}	Drain- gate Voltage (R_{GS} = 20 kΩ)	60		V
V_{GS}	Gate-source Voltage	± 20		V
I_D	Drain Current (continuous) at T_c = 25 °C	20	13	A
I_D	Drain Current (continuous) at T_c = 100 °C	14	9	A
I_{DM}(•)	Drain Current (pulsed)	80	80	A
P_{tot}	Total Dissipation at T_c = 25 °C	70	30	W
	Derating Factor	0.47	0.2	W/°C
V_{ISO}	Insulation Withstand Voltage (DC)	—	2000	V
dv/dt	Peak Diode Recovery voltage slope	7		V/ns
T_{stg}	Storage Temperature	-65 to 175		°C
T_j	Max. Operating Junction Temperature	175		°C

(•) Pulse width limited by safe operating area

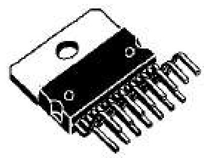
(1) $I_{SD} \leq 20$ A, di/dt ≤ 300 A/µs, $V_{DD} \leq V_{(BR)DSS}$, $T_j \leq T_{JMAX}$

C.5 L298

L298

DUAL FULL-BRIDGE DRIVER

- OPERATING SUPPLY VOLTAGE UP TO 46 V
- TOTAL DC CURRENT UP TO 4 A
- LOW SATURATION VOLTAGE
- OVERTEMPERATURE PROTECTION
- LOGICAL "0" INPUT VOLTAGE UP TO 1.5 V (HIGH NOISE IMMUNITY)



Multiwatt15

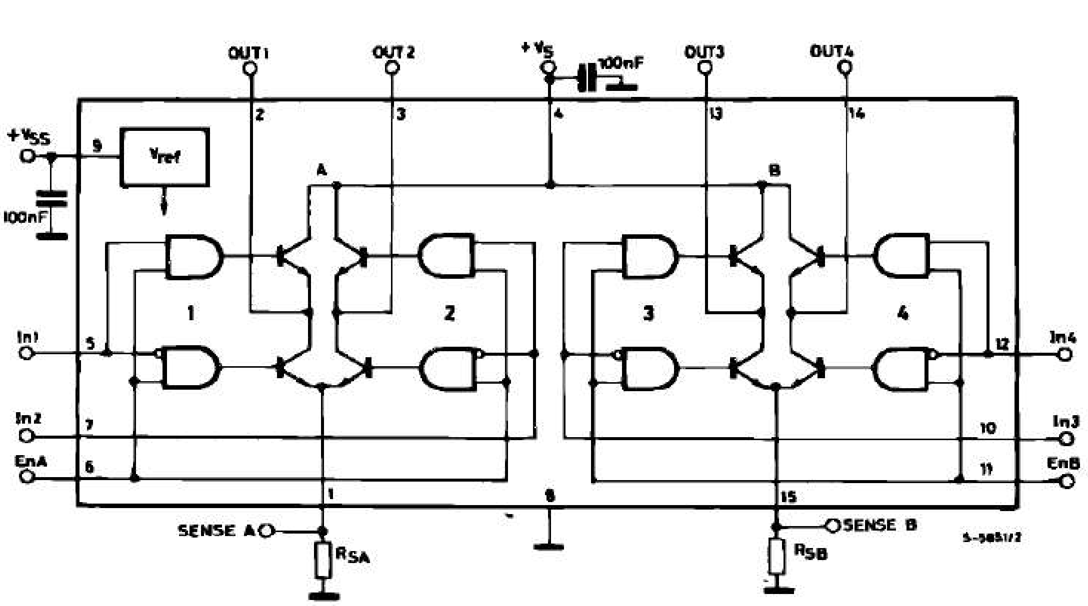
PowerSO20

ORDERING NUMBERS : L298N (Multiwatt Vert.)
L298HN (Multiwatt Horiz.)
L298P (PowerSO20)

DESCRIPTION

The L298 is an integrated monolithic circuit in a 15-lead Multiwatt and PowerSO20 packages. It is a high voltage, high current dual full-bridge driver designed to accept standard TTL logic levels and drive inductive loads such as relays, solenoids, DC and stepping motors. Two enable inputs are provided to enable or disable the device independently of the input signals. The emitters of the lower transistors of each bridge are connected together and the corresponding external terminal can be used for the connection of an external sensing resistor. An additional supply input is provided so that the logic works at a lower voltage.

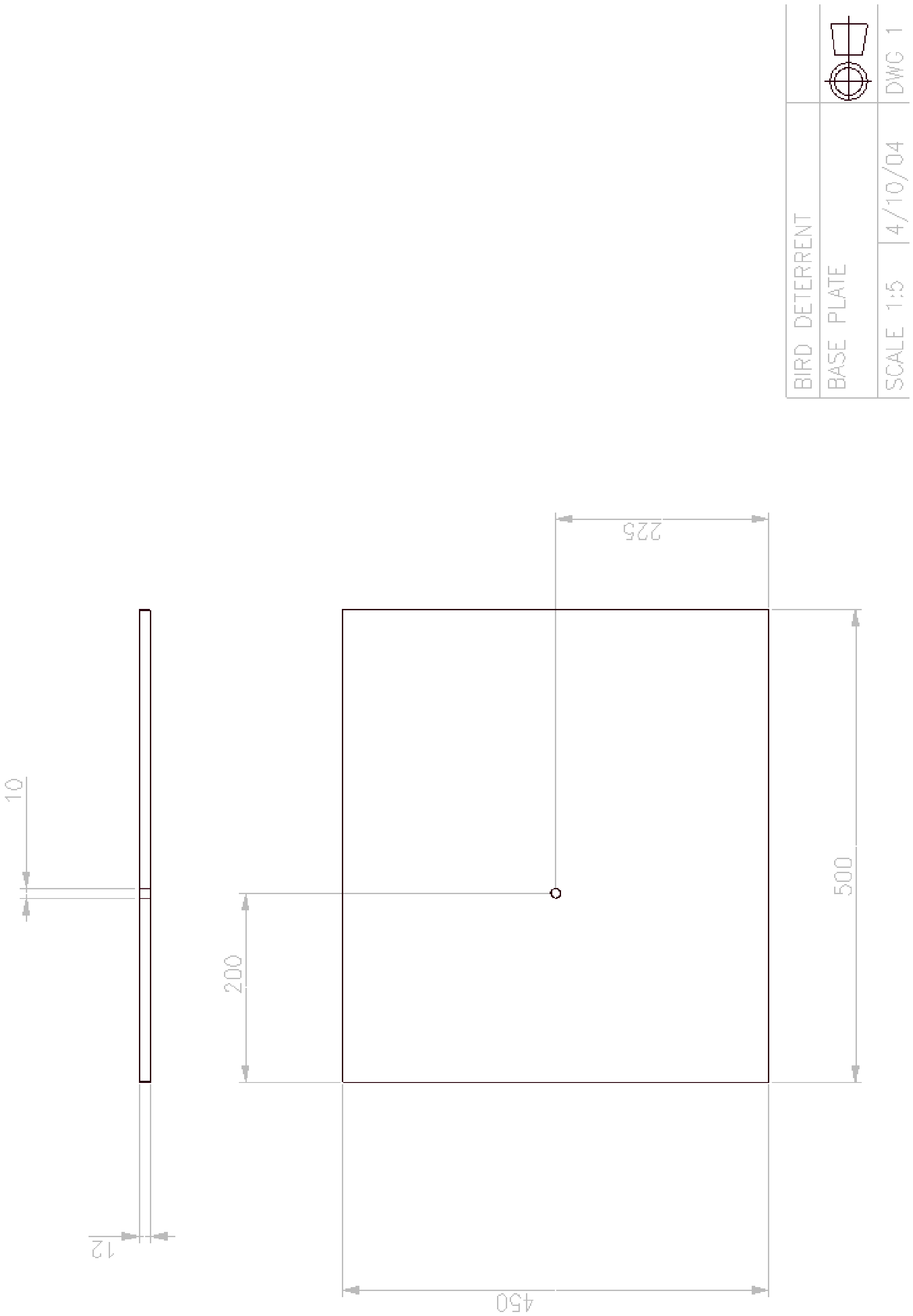
BLOCK DIAGRAM



Appendix D

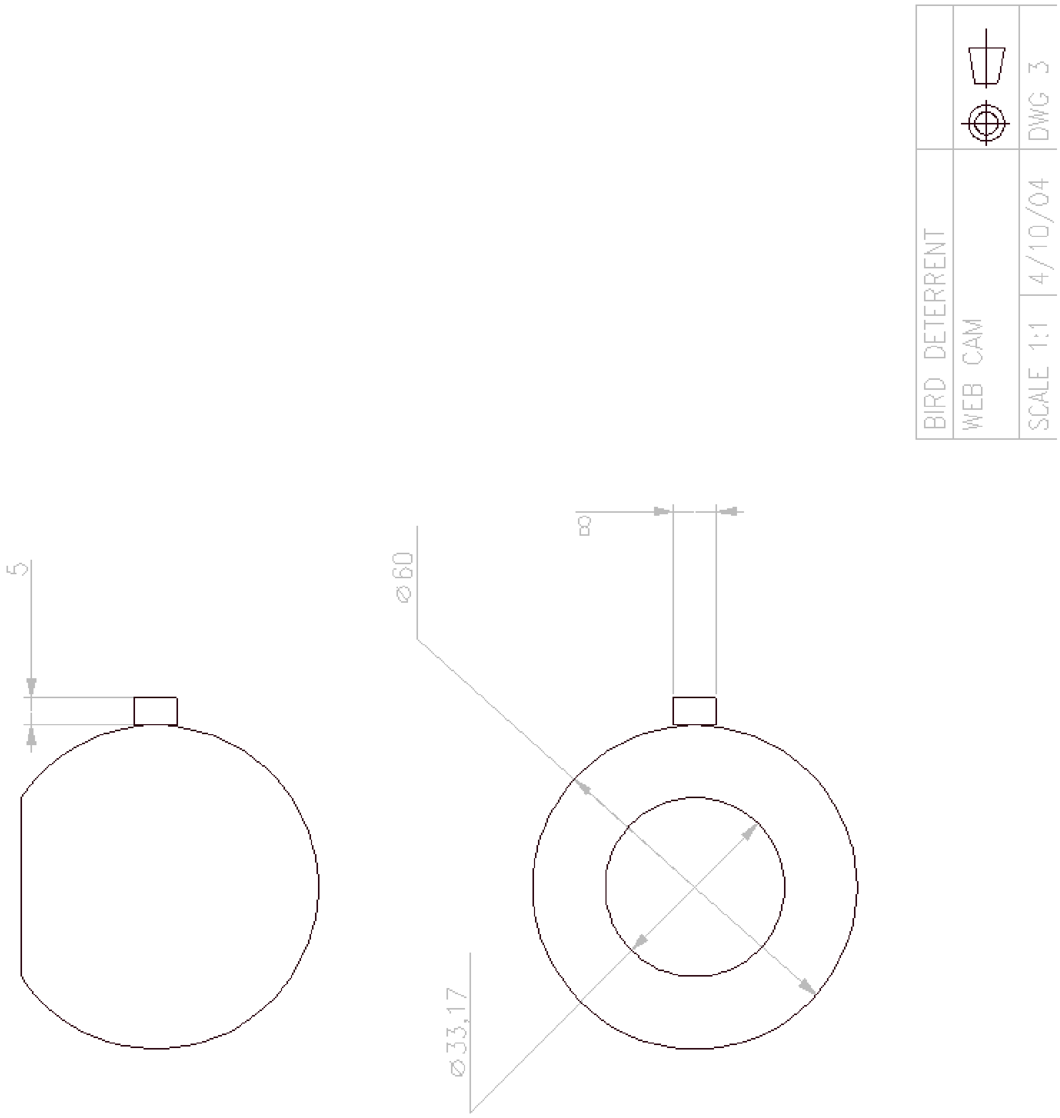
Detailed Drawings

D.1 Base

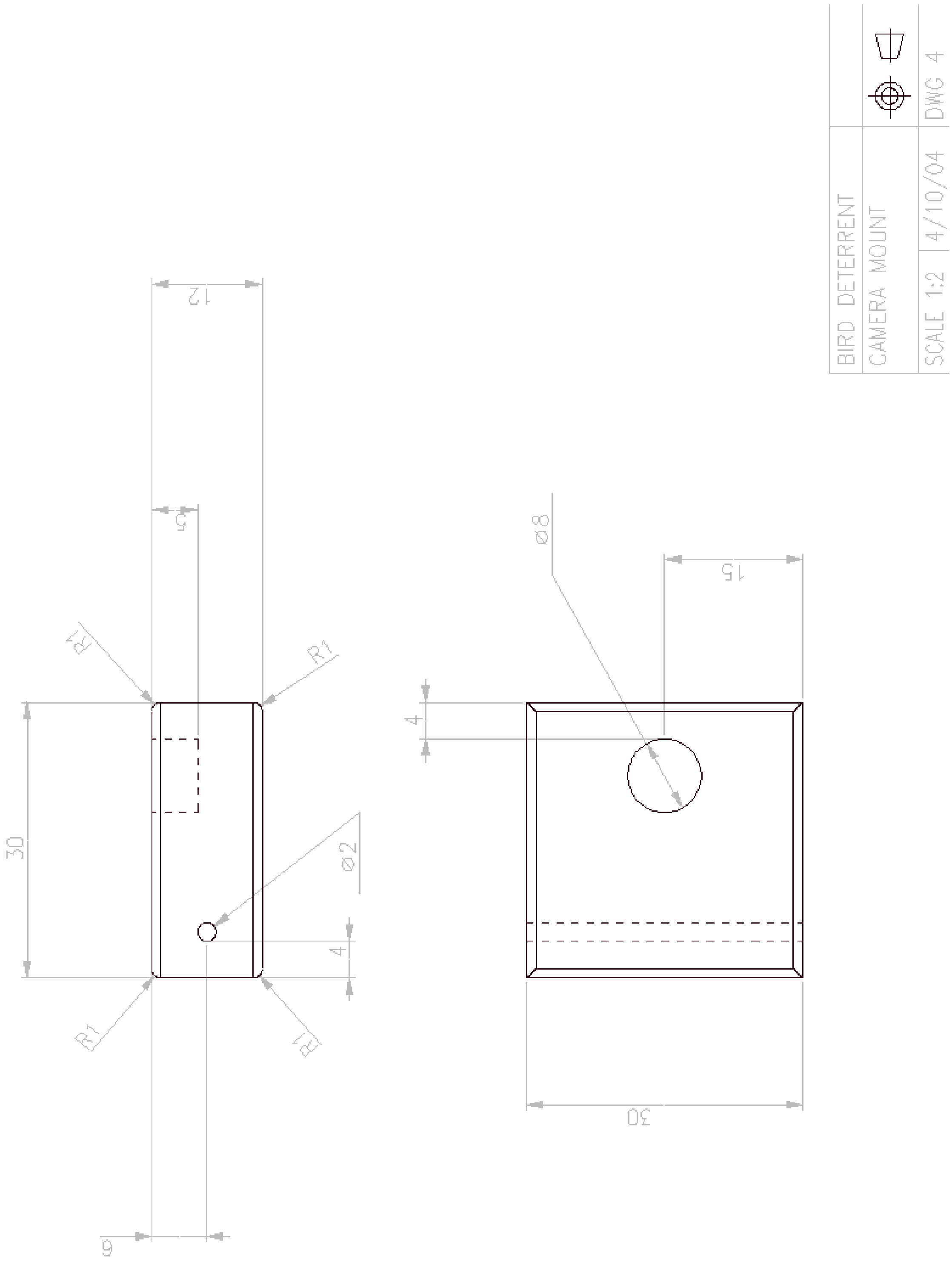


BIRD DETERRENT
BASE PLATE
SCALE 1:5
4/10/04
DWG 1
225
500
200
10
12
450

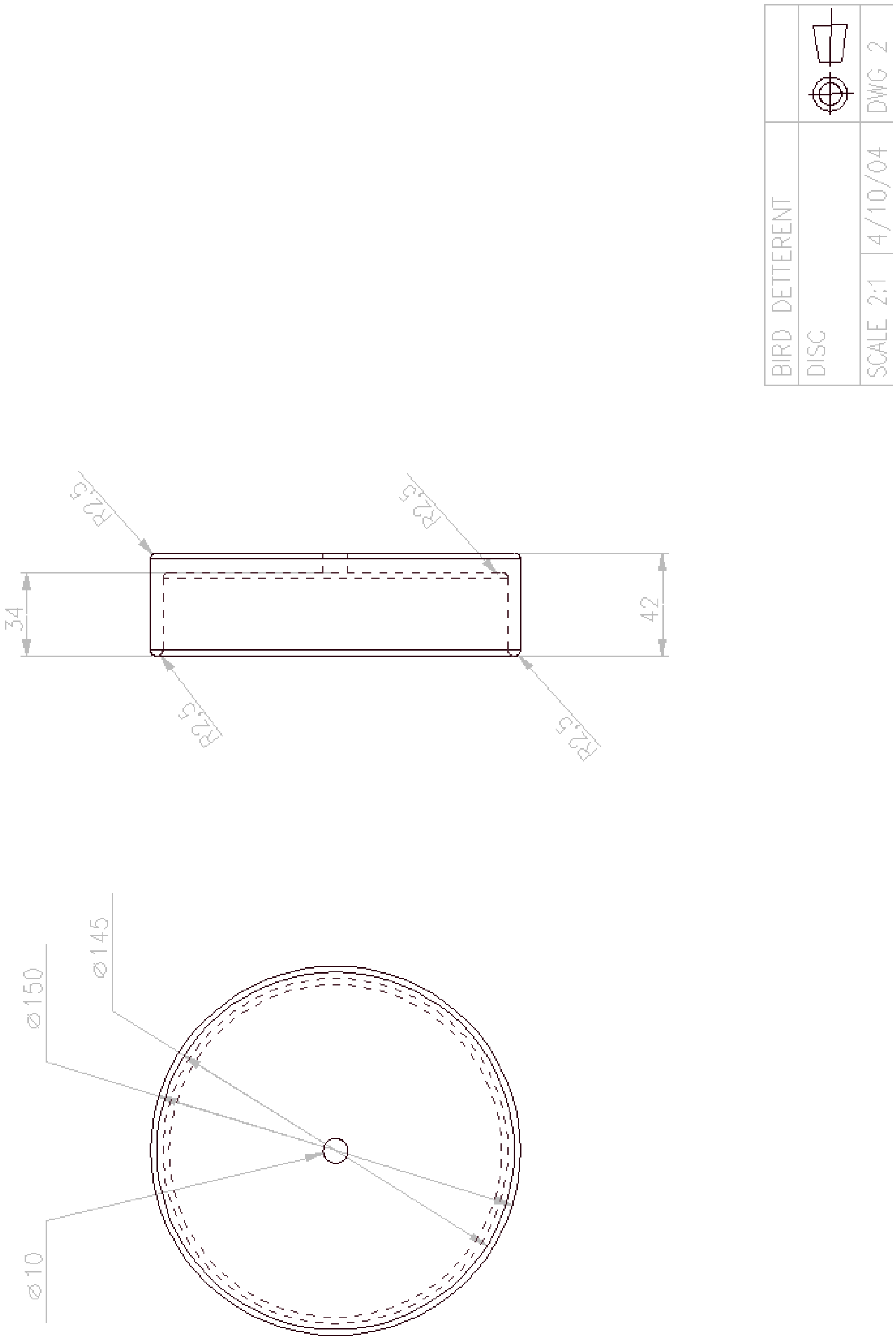
D.2 Camera



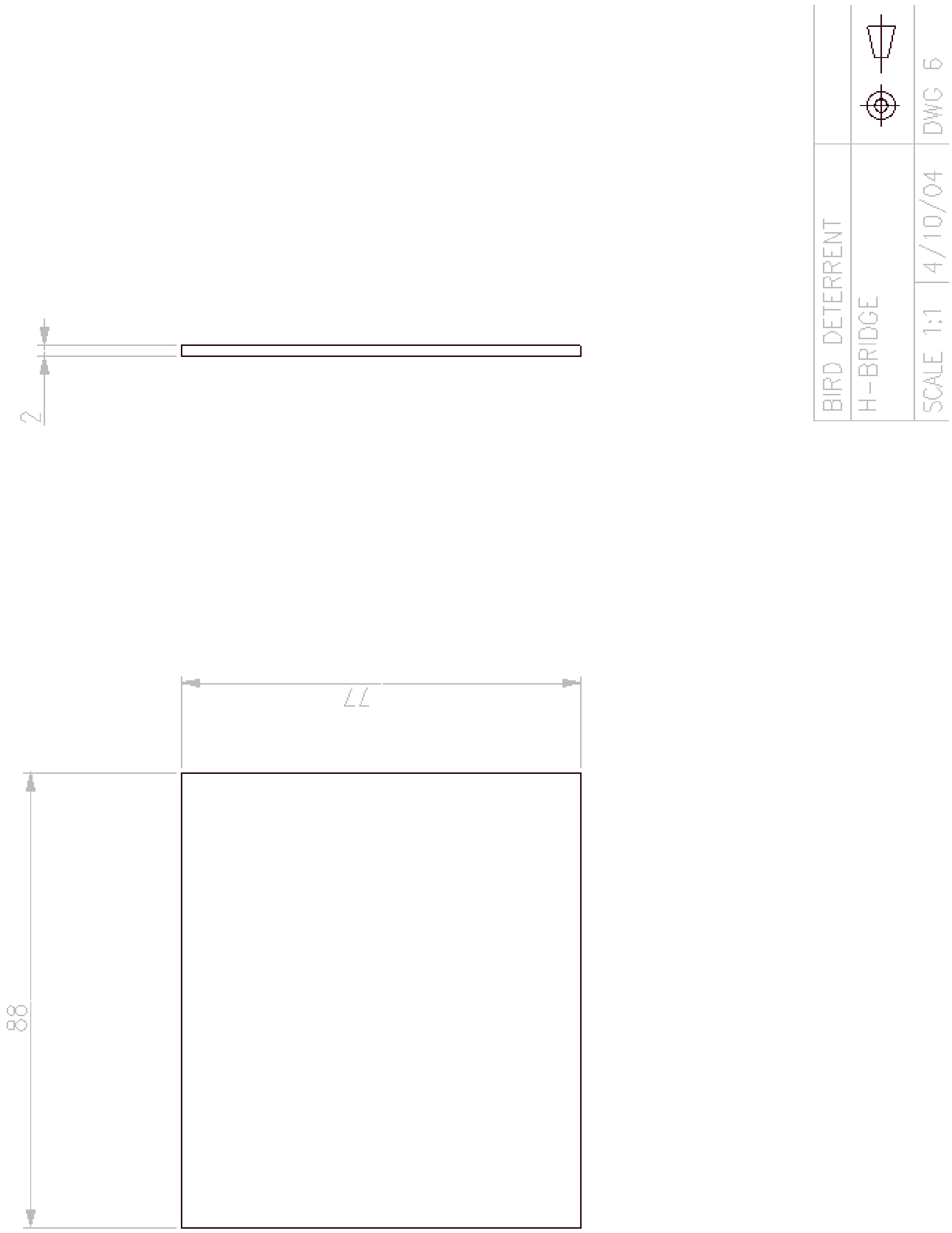
D.3 Camera Mount



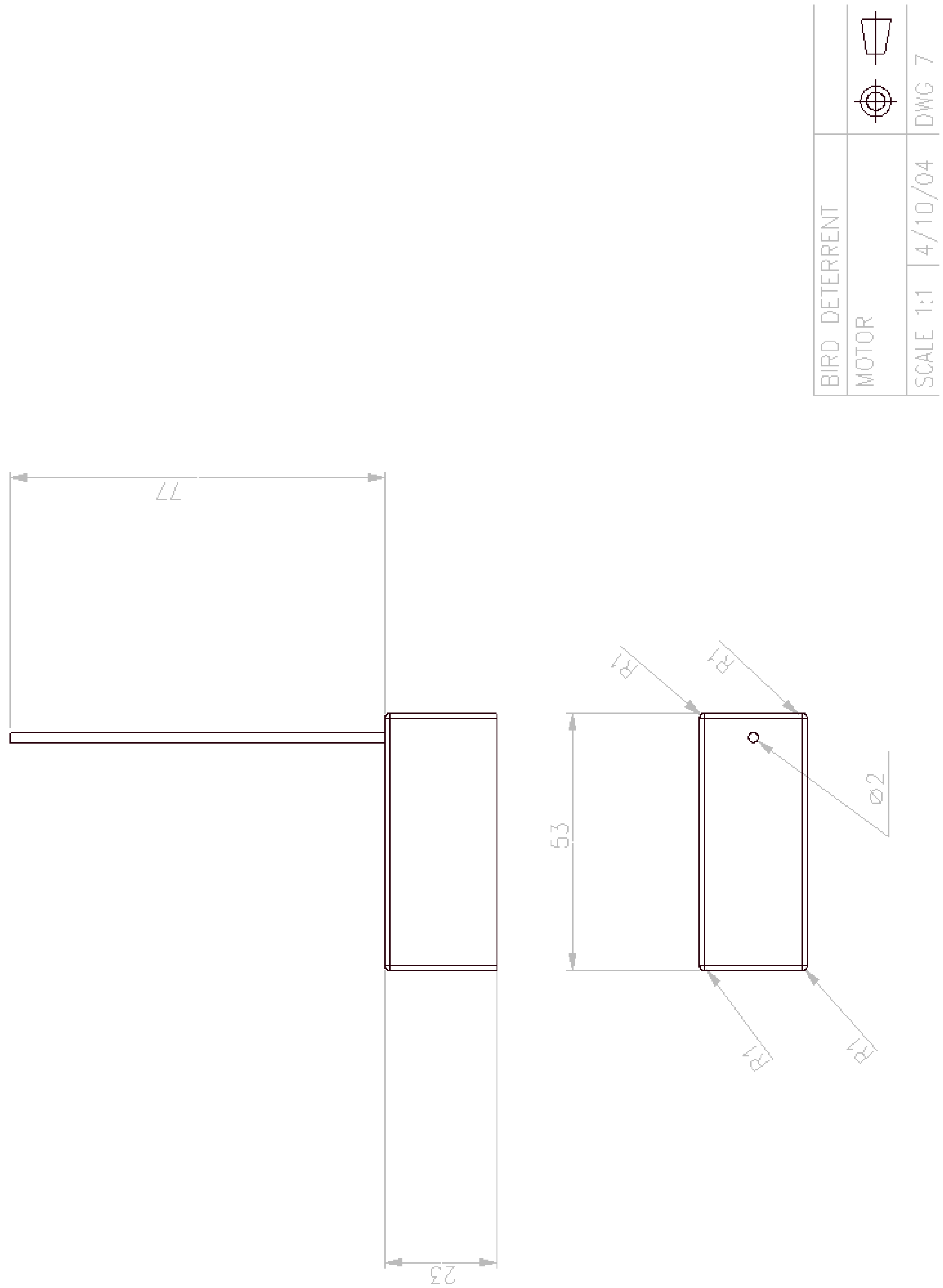
D.4 Disc


BIRD DETTERENT
DISC
SCALE 2:1
4/10/04
DWG 2
R2,5
R2,5
R2,5
R2,5
34
42
ø150
ø145
ø10

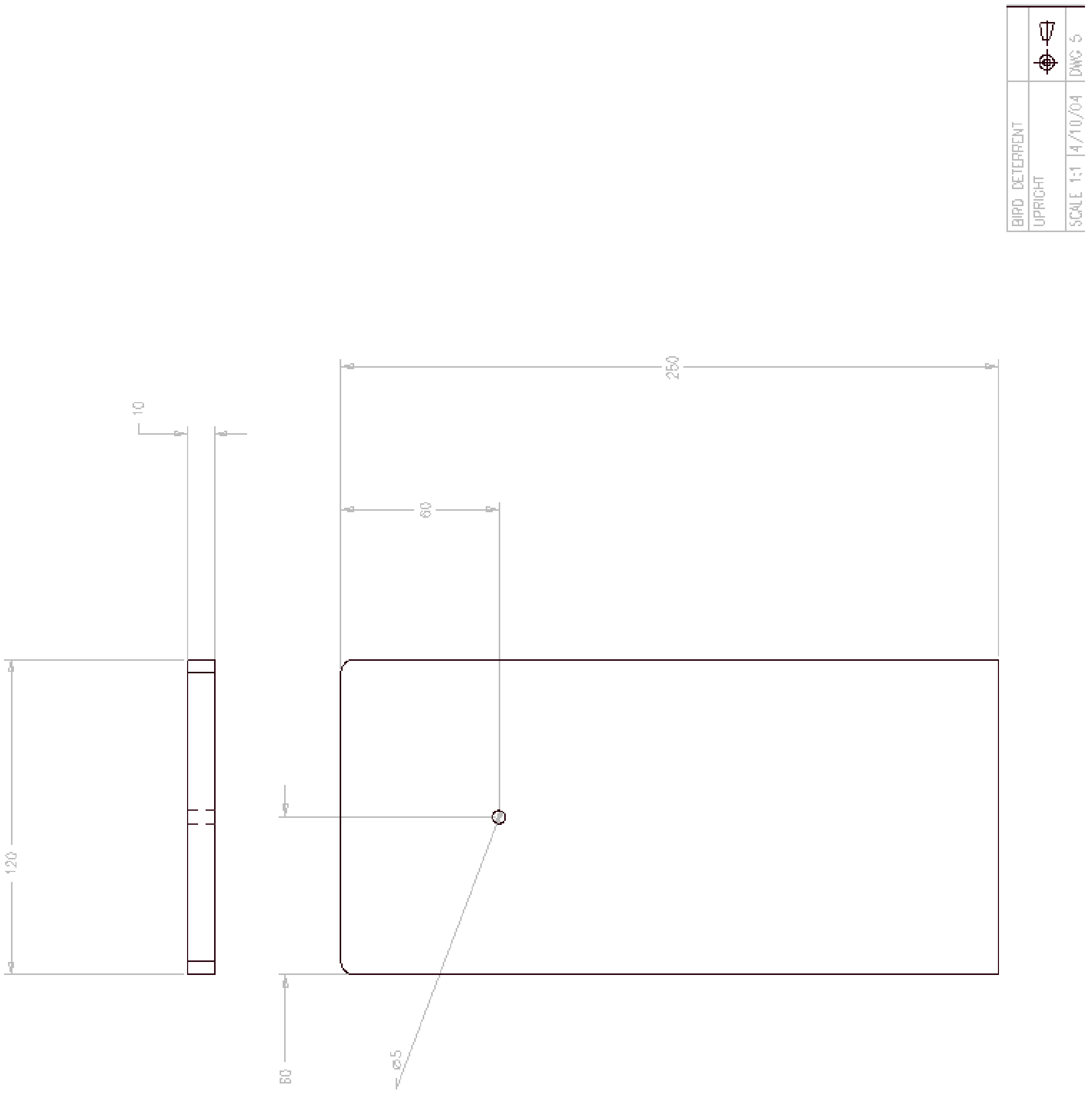
D.5 H-Bridge



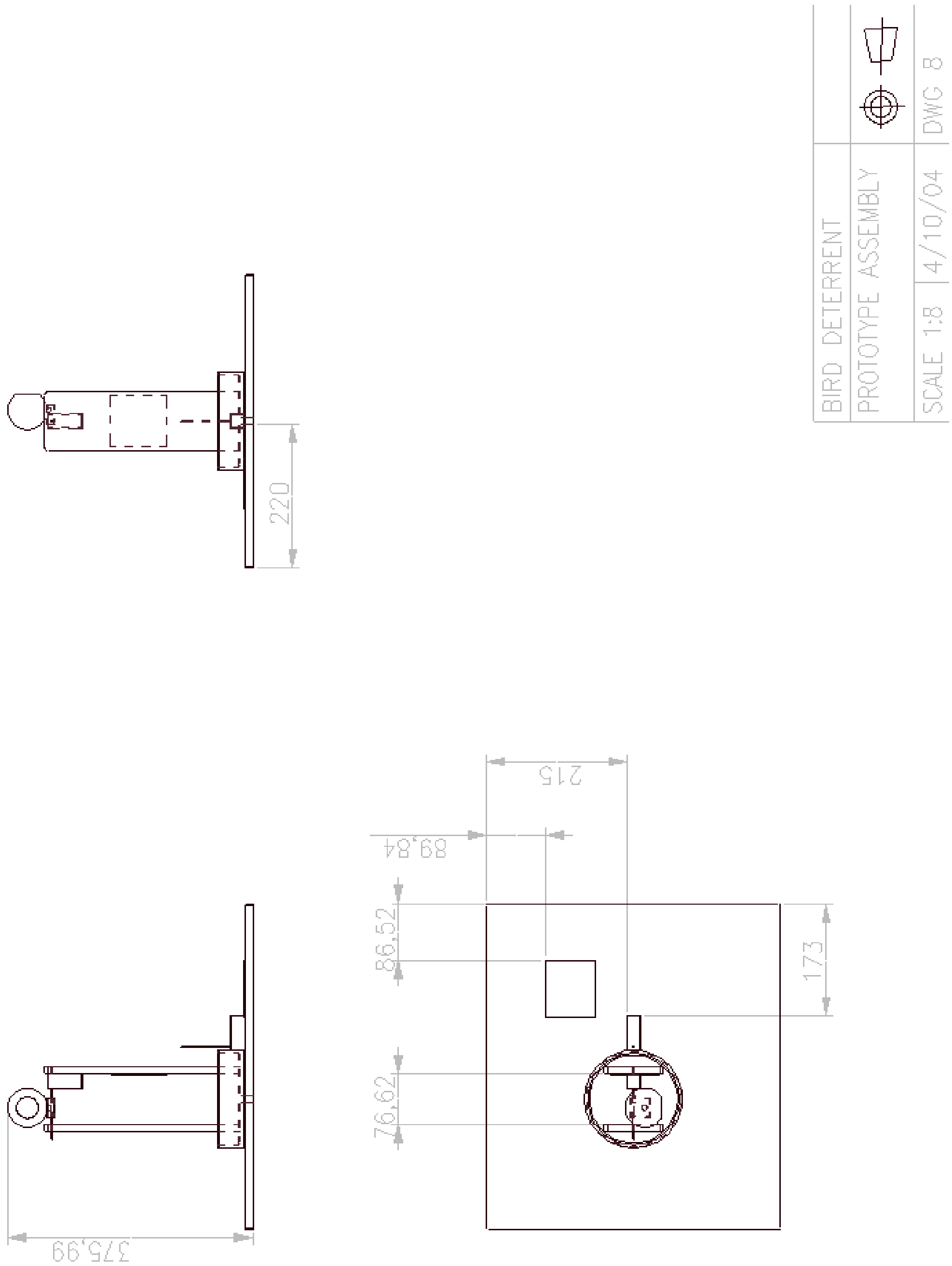
D.6 Motor


BIRD DETERRENT
MOTOR
SCALE 1:1
4/10/04
DWG 7
77
53
23
R1
R1
R1
R1
ø2

D.7 Upright


BIRD DETERRENT
UPRIGHT
SCALE 1:1
4/10/04
DWG 5
250
10
60
120
60
ø5

D.8 Assembly



BIRD DETERRENT
PROTOTYPE ASSEMBLY
SCALE 1:8
4/10/04
DWG 8
220
215
89,84
86,52
173
76,62
375,99