BEAM ROBOTIC

By

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CERTIFICATION OF APPROVAL

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Electrical & Electronics Engineering Programme
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Approved:

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December 2009

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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Natasha Binti Mokhtar

ABSTRACT

BEAM is an acronym of biology, electronic, aesthetic, and mechanical. BEAM is a robotic technology which is simple to apply where it does not required programming. Thus it is based on natural response of the robot. Solar power and neural network of BEAM robotic were studied in this report. Solar power could be used for smaller and less power consume BEAM robot. The neural network was studied as part of the robot brain. The system studied is quadcore and bicore. Quadcore test give the information on how the motor would react from the neural network. There are three photovore had been construct in this project. All these three had different reaction on the light. The project will include the selection design and component to be used to construct the BEAM robot. This report will mainly reflect literature review and result and discussion of this project.

ACKNOWLEDGEMENT

I would like to express my gratitude to all those who gave me the possibility to complete this report.

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CHAPTER 1
INTRODUCTION

1.1 Background of Study

Evolution in robotic had bring world to the BEAM robotic. BEAM robotic is know as a behavior-based robotic. This technology had been developed by Mark Tilden [3]. He had the thought of using simpler control mechanical rather than programming in building robot. This idea of beam robotic is a good approach to developed useful machine with lower cost.

BEAM robotic were design based on the studying of the nature system. BEAM itself are from four words which represent the important concept applied in building BEAM robot [1]:

- **B**iology – BEAM robot are build to mimic the nature system such as the movement and response of the bugs and animal.
- **E**lectronic– Every robot need to have circuit to bring the robot "alive". The electronics design for BEAM are for its brain and were made to be as simple as possible
- **A**esthetics – Neat design will suspend the robot life span. These robots are design to be pretty and neat to make it work better.
- **M**echanics – Mechanical design is as important as electronic design where the mechanical design also involve in controlling the behavior of the robot.

This robotic field does not require complex programming where structure is based on the analog electronic circuit and the mechanical design. Robot inventors look at living creature as their source of idea to design and improving their BEAM robot. BEAM robots are design to be small and the behavior of the robot is based on the reflex from sensor to the nervous network. The robot constructed will reflex and behave as the creature they had imitated.

1.2 Problem Statement

Robotic technology which had been studied and used in university and factory were complex and expensive and huge. These become a factor of limitation for other people to study and learn about robotic. Higher cost meant the robot could not be build individually. Although the subject of robotic design is very interesting, its research and development has been hindered due to its complexity. Robotic technology need to be less in cost and simpler to expand the technology and creativity in designing a robot.

1.3 Objectives and Scope of Study

1.3.1 Objective

- To construct a BEAM robot to do certain task.
- To build a robot using recycle component.
- To study on the use of solar source energy in robotic.

1.3.2 Scope of study

The scope of study will be focused on the design and construction of the robot. The function of the design and the power used in building BEAM robot will be studied and design throughout the project.

CHAPTER 2
LITERATURE REVIEW

2.1 BEAM Philosophies and Rules

The fundamental of inventing BEAM robot were based on these three philosophies [4] :-

- Design the circuit with minimum number of electronics to keep the robot simple and keep cost down.
- Use recycles item which can get from damage electronics machine. Recycled items could lessen the cost for building this robot.
- To use effective power source such as solar power and battery. Solar power is more effective to keep the robot to have longer life span.

Mark Tilden had created the rules [1] of BEAM robotic to guarantee the machine existence. The first rule is to be able to protect its own existence. A robot must be able to keep their energy and maintain enough energy from the power source to keep it "alive". The robot should be able to search for better power sources to avoid powers from becoming low. This is the reason most of BEAM robot use solar panel as its power source.

2.2 BEAM Robot's Brain

BEAM robot does not use programming as its brain, instead it used circuitry as its brain. This brain is also called nervous network [5]. The nervous network is simply neurons (component) joined together, with the output from one neuron becoming input to others until the final output is reached. Nervous network control the motor function.

Sensor are widely used in BEAM robotic. Sensors are used to influence the nervous network and control the robot. Light detector and heat sensors are some of the sensor that could be used for nervous network. The sensor used will directly sent analog signal to influence the analog control circuitry. Machine will give response simultaneously for every sensor input when analog is used as their control system.

2.3 Power Source and Materials

As stated in the BEAM philosophy, effective power source should be used to build BEAM robot. Most of the time battery and solar power were used.

a) Battery

Battery is effective to build a robot with high speed. It has high output which could give more power to the robot. Using battery is easier and the troubleshooting for power problem is simpler. Battery could provide more energy. Bigger robot with higher power consume could be design with battery as their power source.

The disadvantages of battery are that it does not last long. Battery had huge energy but after using it for quite some time, the energy will decrease. The battery need to be change once it was finish which will cost money from time to time.

b) Solar Power

The never ending power source are the most effective power sources to invent a robot which has long life span and could maintain their energy source. Solar power is used as BEAM power source because the energy supply by light could be change into electricity. Solar cell was used to convert this energy to electricity. This energy could be used on its own or to recharge the robot's batteries [2] Light had transfer a huge amount of energy but only 3.4% [1] of this energy could be change to electricity.

Both solar and battery power could be combined to make a robot which consume high power. Rechargeable battery could be used by recharging it using the source from solar panel. This could lower the cost and at the same time expanding the life span of the robot.

BEAM robotic does not require complex design. As for material, the components use are commercially available and do not require special components. Some of the electronic components can be taken from existing discarded electronic circuits.

2.4 Evolution of BEAM Robotic

It stated in the law of BEAM robotic that a robot must keep its existence. Hygiene [5] is a must to achieve this goal. Keeping it away from any dirt is a difficult task when the robot moves around freely. Robot should be able to deal with dirt which might damage its function. It should maintain its hygiene in order to keep its life span longer. Building a robot which could keep its hygiene will make a huge step toward advanced life form.

Another step to achieve a life form robot is to build a robot with vision. A robot with light seeking vision could be invented. It is better if the vision could identify solid so that they could avoid anything within their vision.

2.5 Walker

Walker is a walking device which had been implied in BEAM robotic. This device is build to imitate the behavior of a living creature which is moving using legs. The robot is made so that it will move by alternating ground-contacting legs. There are many types of walker being develop from 1 to 12 motors walkers.

Bicore [7] and quadcore is commonly used as the neuron system for this robot. Bicore and quadcore is a nervous network consists of few neurons connected output to output and performs as a simple oscillator. A grounded bicore is shown in Figure 1.

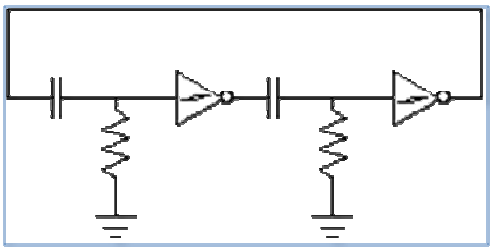

Figure 1 2 Nv neuron loop

2.6 Photovore

A light seeking robot is call a photovore. The knowledge of light seeking robot had been known for so long but the robot technologies which apply this function were much more complicated. As this had been a problem, BEAM robotic had make it possible to build light seeking device without too much complication. As BEAM is a behavior-based robotic [6], the design of photovore in BEAM is based on simple reaction which reflect to the movement of the robot. There are many types of photovore. The movement of the motor would depend on the light sensor such as photodiode.

Figure 2 show one type of photovore [9]. The motor of this photovore will response to the photoresistor which are at the same side of the motor itself. For example, right motor will response to the right photoresistor. As the light is brighter on the left, the left motor will become slower and the right motor were speed up and lead the photovore to the left side. The two photoresistor were compare to each other so that the output will respond according to the light density.

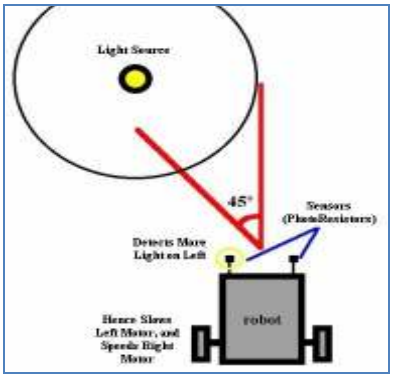

Figure 2 Photovore

Another type of photovore has the split brain [9]. The motor will response to the sensor of the opposite side. No comparison had been applied in this type of photovore. The right motor will directly response to the left photoresistor. The power given on right motor is higher so the motor will become faster while the left motor speed will remain the same.

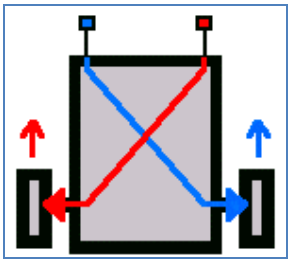

Figure 3 Photovore with split brain

In BEAM robotic, the behavior of photovore which seeking for light is important especially for solar powered robot. Photovore which used battery could become a robot which seek for light to avoid the obstacle which blocking the light. Photovore are suitable to build in BEAM robotic as the light sensors are cheaper [1] and the easiest to find. The sensor used could be photodiode which detect light and photoresistor which its resistance as response to the amount of light receives. These components are widely used in many application and they are reliable.

CHAPTER 3

METHODOLOGY

3.1 Procedure Identification

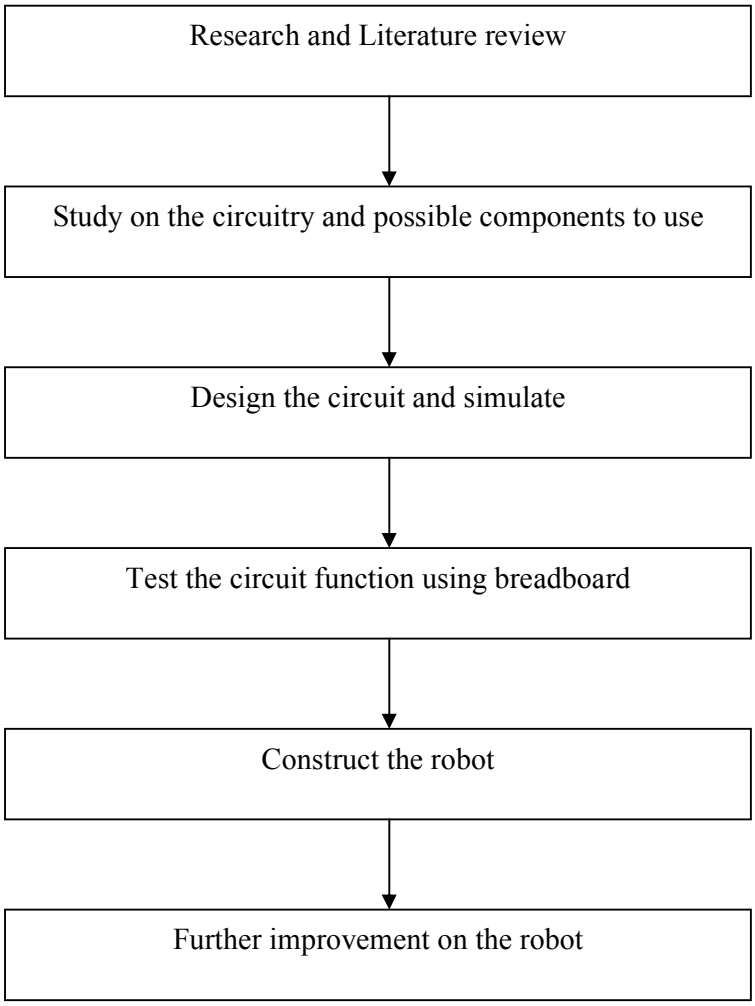

Figure 4 Project activities

Table 1 :Gantt Chart on work progress

FYP I

No	Detail/Week	1	2	3	4	5	6	7	8	9		10	11	12	13	14	15
1	Selection of project topic																
2	Preliminary research work																
3	Submission of preliminary report																
4	Detail research and data acquisition on components																
5	Submission of progress report																
6	Seminar (compulsory)																
7	Data analysis and development of model																
8	Submission of final draft																
9	Submission of interim report																
9	Oral presentation																

Mid-Semester Break

FYP II

No	Detail/Week	1	2	3	4	5	6	7	8	9		10	11	12	13	14	15
1	Continue on modeling prototype																
2	Submission of Progress Report																
3	Populate the data																
4	Seminar (compulsory)																
5	Further improvement and look for area of enhancement																
6	Poster exhibition																
7	Submission of dissertation (soft bound) and technical report																
8	Oral presentation																
9	Submission of Project Dissertation (hard bound)																

Mid-Semester Break

3.2 Research and Literature Review

Research had been carried out on the power used for the BEAM robot. Other research on BEAM robotics is on nervous system, motor driver and the suitable power source for BEAM robot.

3.3 Study on circuitry

Circuit for solar engine and quadcore had been investigated to determine the used of the circuit in the project. A motor driver circuit is also being built using 74LS240N. The circuit is tested with one motor walker.

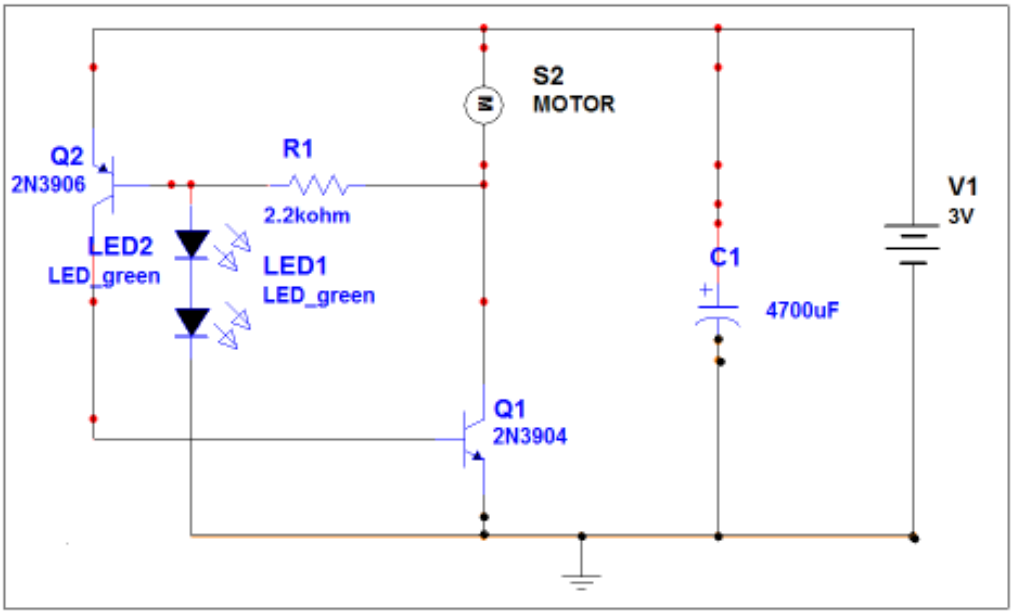

Figure 5 Solar engine schematic

3.4 Test the circuit.

All the circuits had constructed on the breadboard to validate the function of the circuit. The circuit of motor driver was tested for the voltage suitability which could be used for the circuit to drive the motor. The result of the test will be discussed in Chapter 4.

3.5 Construct the robot

Construction and testing of the robot is still in progress. There problems caused by unavailability of components. The other problem is to minimize the weight. This problem will be follow up along the progress of this robot. The robot will be assemble by using prototyping PCB and “freeform”, a form where all the component is assemble on the IC’s lead.

Veroboard and aluminium were used in constructing the robot. The veroboard were not stable so the circuit might not function well for some time. The aluminium was used as the base for holding the battery and the circuit.

CHAPTER 4
RESULT AND DISCUSSION

4.1 Solar engine

Solar engine had been design to achieve more power using solar power source. It acts as a control which converts low power to more powerful pulses. The pulses from solar engine were used to power on the motor and move the mechanisms of the robot. Figure 5 shows the schematic for solar engine.

Simulation for the solar engine had been done and the result as in Figure 6 below. Multisim is use for the simulation. Solar panel component are not available for this software. Instead of solar panel, DC supply was used. DC supply could replace the solar panel on this simulation because solar panel also supplies DC power. The graph show the voltage on second point of the motor is less than power supply. The result show that the motor is working.

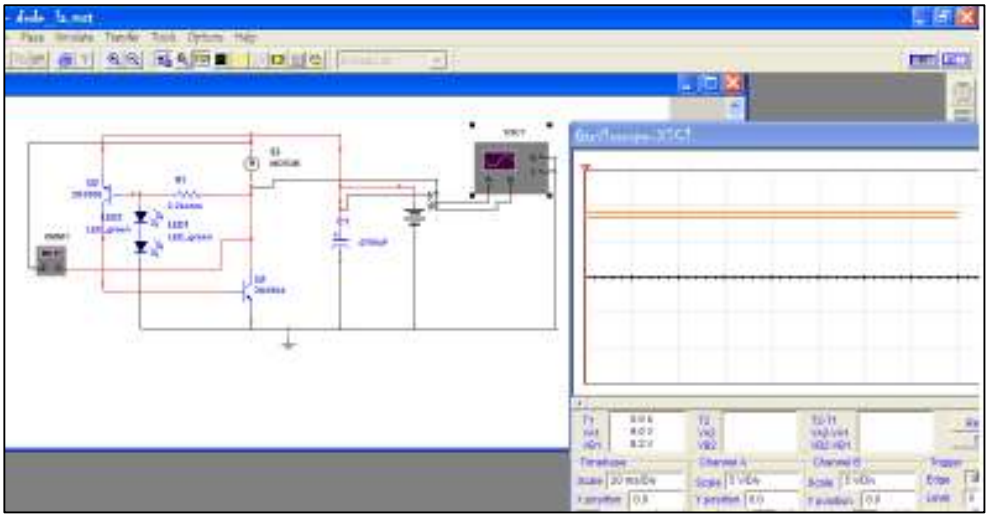

Figure 6 Simulation of solar engine

The solar engine was constructed on the breadboard to see the function of this circuit. The solar panel was not available at the time so it had been replaced by a battery. Different value of capacitor had been used to test the circuit. Capacitor used in Figure 7 was 1mF. Table 1 show the result for different capacitor used for the circuit. The Led will be dim when the motor is trigger.

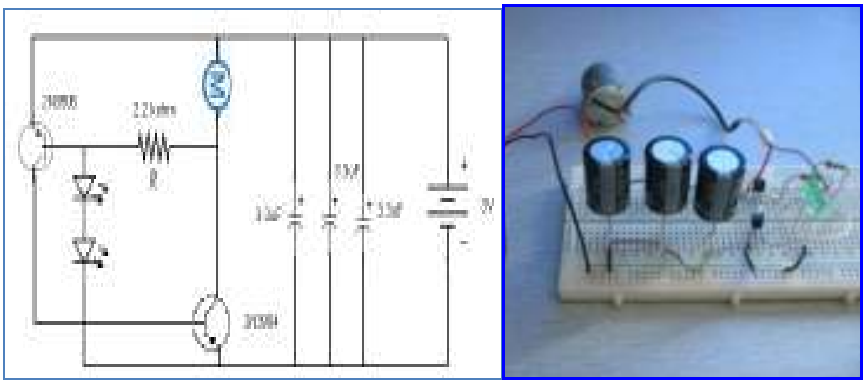

Figure 7 Schematic and tested Solar engine

Table 2 : Result on LED and motor for different capacitor value.

Capacitor Value	**Result**		
	Led	**Motor Trigger**	**Motor**
3300uF	40mA	160mA	80mA
4700uF	24mA	160mA	80mA
1mF	20mA	180m A	80mA

Theoretically the capacitor is use to store energy for the motor use. The capacitor will be charge by the power source given by the solar cell. It will discharge to the motor when the voltage had achieved the threshold voltage. This process will keep on as long as there are light from the sun or the capacitor is damage. The test is done using battery so the result might not be the same as using solar panel.

Solar power is suitable for BEAM robotic as most of BEAM robot did not consume high power. Robot which consumes more power use battery where it is more suitable. Table 2 shows the advantages and the disadvantages of using solar power.

Table 3 : Advantages and disadvantages of solar power

Advantages	**Disadvantages**
Long life span (Rechargeable)	Expensive – need lots of panel for high power
Light Weight	Low power
Free source	-

The voltage of a single solar cell is 3V. The energy of the solar cell is determined on the exposure of the light. Little exposure means lower voltage. The current is not high enough to drive the motor for a one motor walker. Higher value of capacitor and mere number of solar cells needed for the walker

4.2 Quadcore and Bicore

Quadcore was built as the nervous net of the robot. Quadcore circuit was constructed to validate the quadcore function as the brain of a robot. Figure 8 show the schematic of the quadcore. The quadcore was build using Schmitt's inverter for clean transition.

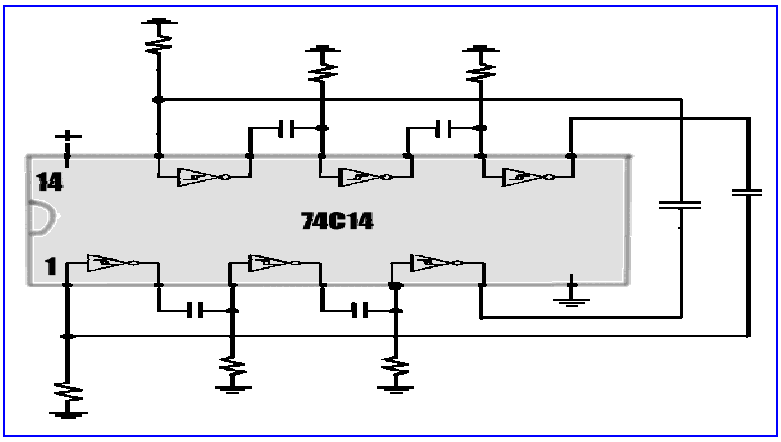

Figure 8 Quadcore

The circuit was tested on a breadboard to see the role of the quadcore. IC 74HC14 were used in order to built the circuit. The circuit had been design slightly different from the schematic in Figure 8 as to see clearer the function of the quadcore. LEDs had been added at the output of the Schmitt's inverter to see the output as in Figure 9.

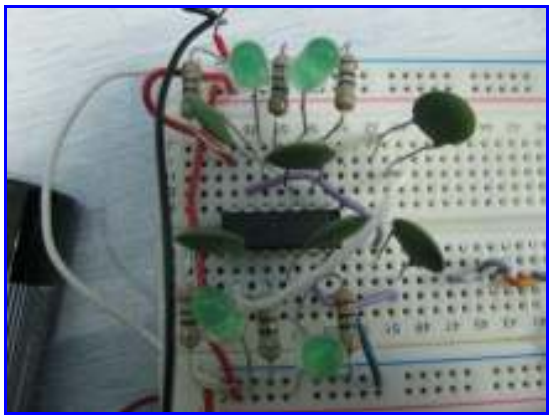

Figure 9 Quadcore with LEDs.

The LEDs were added to each output which are at pin no 2, 4, 6, 8, 10, and 12. The circuit was constructed to make it more visible to see the function of the quadcore. The LED will show the response of the inverter. All the inverter were loop to each other. Three of the inverter will have the same output at one time. The LEDs show the functioning inverter for this quadcore.

Table 4 : Result for quadcore circuit.

74HC14 PIN	LED RESPONSE DUE TIME			
2	ON	-	ON	-
4	-	ON	-	ON
6	ON	-	ON	-
8	-	ON	-	ON
10	ON	-	ON	-
12	-	ON	-	ON

The table shows that two inverter which are adjacent to each other will not have the same output at the same time. This is because the neighboring inverter's output will be opposite to each other. The quadcore will be oscillated until the power is off. Adding a motor driver to this circuit will make it suitable to be used to change the direction of motors. Quadcore could be used to run for two different motor.

Bicore is another neural network for BEAM robot brain. Bicore has the same function as quadcore except bicore only consist of two inverters. Bicore will oscillate and the outputs of both inverters are opposite to each other. There are two type of bicore which are grounded bicore and suspended bicore. Suspended bicore could be used as a circuit for sensor. The circuit are useful for detecting light as the duty cycle of the bicore output signal will change based on the comparison of two light sensor [8]. Circuitry for suspended bicore is shown in figure 10

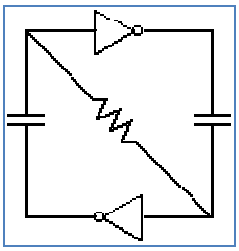

Figure 10 Suspended Bicore

4.3 Motor Driver

The motor driver [4] built using an IC of 74LS240N which is a Octal Buffer / Line Driver with Tri-state Outputs ICs. The IC was used to maximize current capability. The circuit was made for a one motor circuit where both enable line is connected to ground. This application is for one motor driver where the connected motor will run at higher speed. Figure 11 show the picture of the circuit that had been constructed.

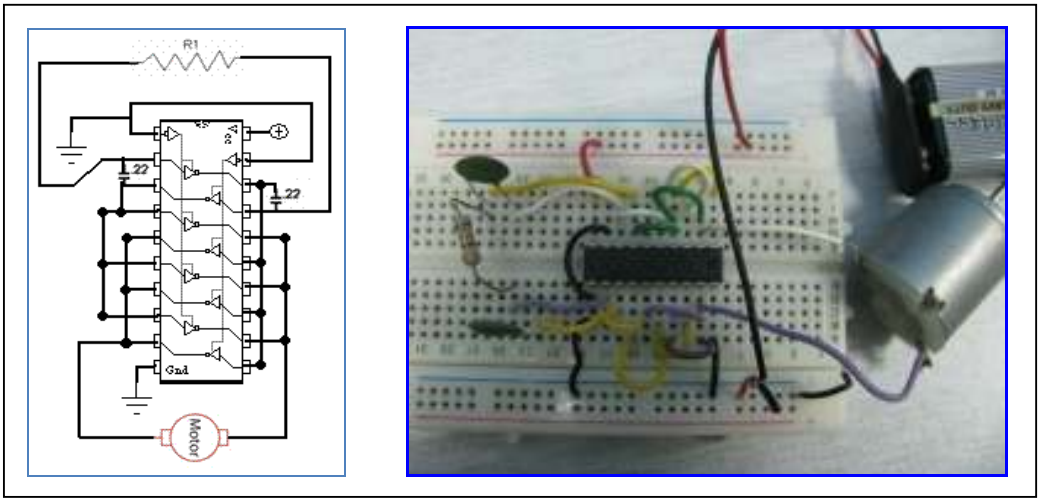

Figure 11 Schematic and tested circuit of motor driver for one motor.

This circuit was tested for the power required to move the motor. The circuit will started to work for voltage supply at 4.6V. The result of the test and the comment had been put in Table 4. The problem of the power might due to the current. Theoretically mound another 74LS240N would boost the current of the circuit. The problem of the voltage supply might be reduced by stacking another IC.

Table 5 : Result of power supply.

Power Supply	Comment
3.5V	Not enough power
4.0V	Not enough power
4.5V	Need some force to drive the motor. Not enough power.
5.2V	Need some force to drive the motor. Not enough power.
6.0V	The motor started but with very low torque.
6.5V	The motor move faster

The circuit needs two capacitor, one resistors and an IC. This component could be constructed by short circuited and soldering the capacitor and resistor to the IC to reduce space and weight. Five trial to freeform the IC had fail where the IC socket were damage. The pins were bent before it being soldered. This had made the layer which could be soldered easier to pull off which make the pin could not be solder. As a result circuit board had been used to reduce any more damage.

There is another fault occurred where the motor move only in one direction. This mean the bicore is not functioning. The reason is unknown. Another circuit had been made to confirm the function of this circuit. The second circuit constructed by using two chip which are 74LS240N and 74HC14N. The two circuit had the same circuit where six inverter act as the motor driver and two inverter as bicore. The motor from second circuit driven forward and reverse as it suppose to. Reason for the fault is still unknown. Figure 12 show the circuit of 74LS240N standalone motor driver and the two chip circuit of bicore and motor driver.

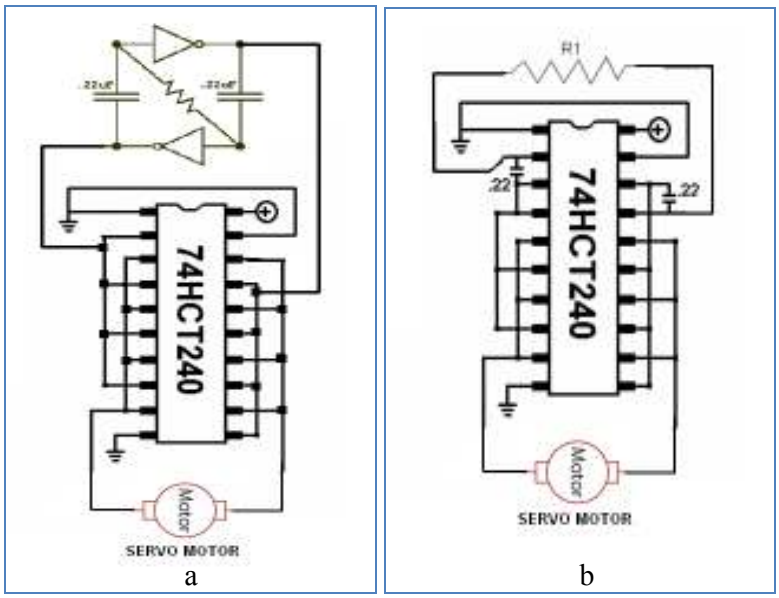

Figure 12 :a-Circuit with IC 74LS240 and 74HC14N. b-Circuit with only 74HC14N

4.4 The Body

The body of a one motor walker been built. The body was built using modified servo motor. The gears need to contact to move the walker. The material used is not suitable as the gears used are thin so it is hard to meet each other. If the alignment of the gear off for 1 or 2mm it will affect the movement of the walker. Figure 13 shows the gears used.

Figure 13 : Thin gears.

4.5 Photovore

Photovore was a robot which will react due to the light. Three type of photovore had been build for the second part of final year project. All of the photovore will change their direction toward light when the source of light was blocked. Table 6 shows the comparison of the three photovore.

Table 6 :Comparison of photovore's response toward light

Photovore 1(P555)	**Photovore 2 (P386)**	**Photovore 3 (P4LDR)**
-Assemble on veroboard	-Assemble on veroboard	-Assemble on veroboard
Left motor will slow down or stop when left LDR don't get any light.	Left motor will slow down or stop when left LDR don't get any light.	Motor will change direction when one of the LDR don't get any light.

4.5.1 P555

This circuit work based on the comparator within the N555 chip. This circuit compares the voltage from the LDRs as the resistance of the LDR is high when there was no light. The IC will compare both inputs from right and left LDRs.

The circuit had been assembled in two form. First form is in a freeform which mean that the circuit was assembled standalone without using any board. The soldering was made on the IC holder itself. Figure 14 show the freeform circuit. This circuit did not functioning well. Only one motor were able to move. Due to this problem the photovore move only in one direction.

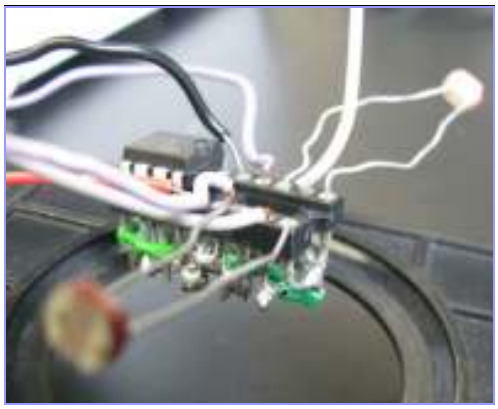

Figure 14 Photovore 1 P555 (freeform)

The same circuit was assembled on a veroboard. Both motor moves. When the left LDR was covered the right motor will move faster. The problem occurs when right LDR being cover the motor did not response. The result was the same even when the LDRs where change to photodiodes. Refer Appendix A for schematic circuit.

4.5.2 P386

LM386 chip is a low voltage audio amplifier. The chip is used in a speaker to amplify and provide equality of the output. Pin 1 and 8 are the gain pin which were connected together to boost the signal. The circuit works by equally divide the output. For the photovore, two motor were connected to the output. In this case, the output will be equally divided to both motor.

When one of the LDR gets lesser amount of light, the output voltage will drop. The output voltage will run one of the motor while the other motor will run by the voltage remaining from voltage supply. For example, if the input voltage is 6V and the output of the chip is 4V, one of the motor will run on 4V and the other one on 2V. Refer Appendix B for schematic circuit.

The circuit was assembled on veroboard. Pin 1 and 8 were soldered together. The motor will move forward when both LDR where expose to light. The motor will response to both LDR but only one motor were affected. When any of the LDR were cover the left motor will slow down. So for both condition the robot will move to the left. The component had been change from photodiodes to LDRs. Figure 15 show the assembled photovore LM386

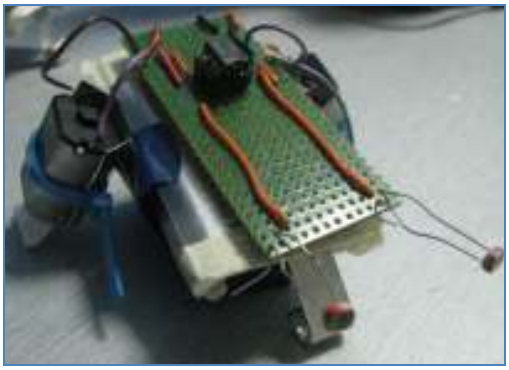

Figure 15 Photovore 2 P386

4.5.3 P4LDR

This circuit was using Schmitt inverter. The circuit consists of NOT gate where the photovore would change the direction of the motor. The LDR will determine the value of voltage through the chip. The motor will change its direction when there is different amount of light at any LDR. The inverter gives response to the value of the voltage input from LDR.

P4LDR had been assembled. Four LDR were used, two for the front and another two for each side. The motor will change direction when the LDR where covered. Left motor response to left LDR, while right motor response to the right LDR. The circuit will move forward until one of the LDR had receive more light than the other.

Problem occurs in this circuit where the circuit is not stable. For every test conducted to the motor, only two LDR will function. The functioning LDR keep changing. Labeling the LDR with 1 2 3 4. For the first try only LDR 2 and 4 will make the motor change direction. On another trial, LDR 1 and 4 are functioning while the motor will not response to LDR 2 and 3. Assembled P4LDR is shown in Figure 16.

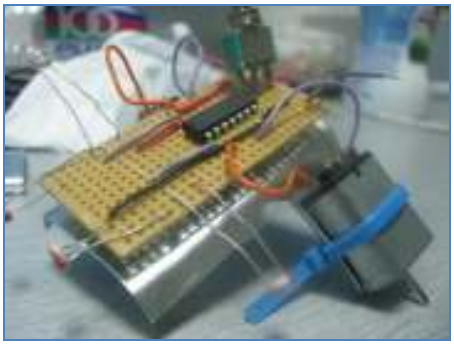

Figure 16 Photovore 3 P4LDR

This problem had made the photovore move forward and backward due to the unstable amount of light being capture by the LDRs. The problem of the photovore might also cause by the sensitivity of the light detector device. The sensitivity can vary with just a slight different in the length of the LDR lead. Refer Appendix C for schematic circuit.

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CHAPTER 5
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In summary the power supply and the brain for the robot are important to build a BEAM robot. Study on both solar power and quadcore are useful this project. The solar engine could be used to build small power consumption robot while the quadcore could be use as nervous network for robot which make the motor to change their direction. Better understanding on quadcore and solar panel is needed for this project as both of this could be combined to build a robot. The driver circuit is needed to move the robot and give enough power for the robot to do its job. The problem might occur due to the veroboard which are not stable. Sometimes the component itself had a slight difference in their performance such as the motor RPM.

5.2 Recommendation

The next step on this project is to study on other possibility for building BEAM robot. The material used need to be improved and the problem in constructing the circuit and robot to be solved. Every circuit needs to be constructed neatly so that the sensitivity of the sensor will not differ too much. This project could be continue by combining BEAM robotic with PIC controller to make a robot which could perform more function.

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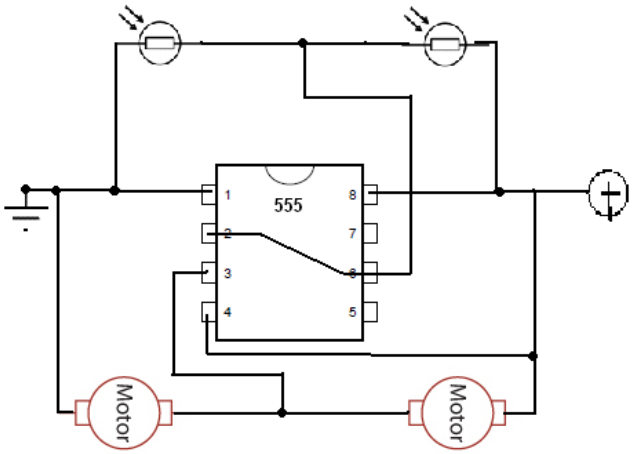
APPENDICES

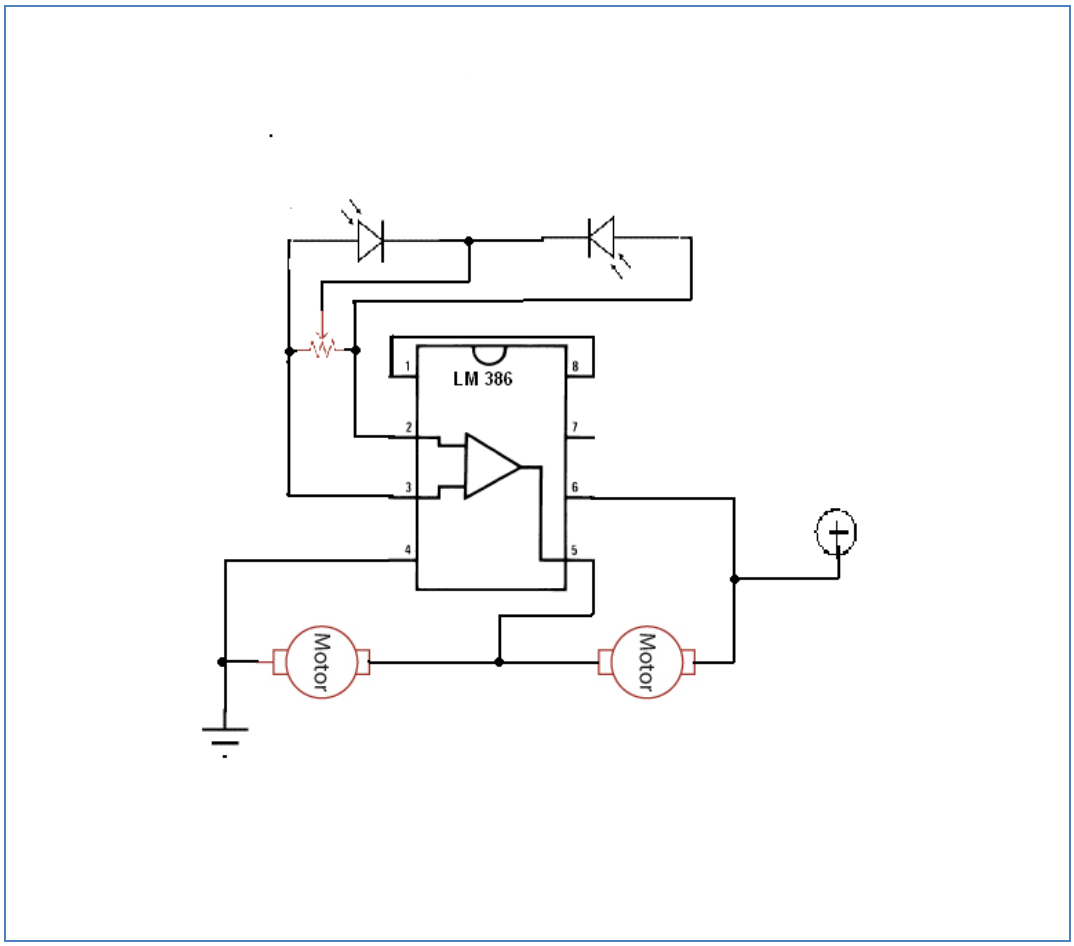
APPENDIX A

CIRCUIT P555



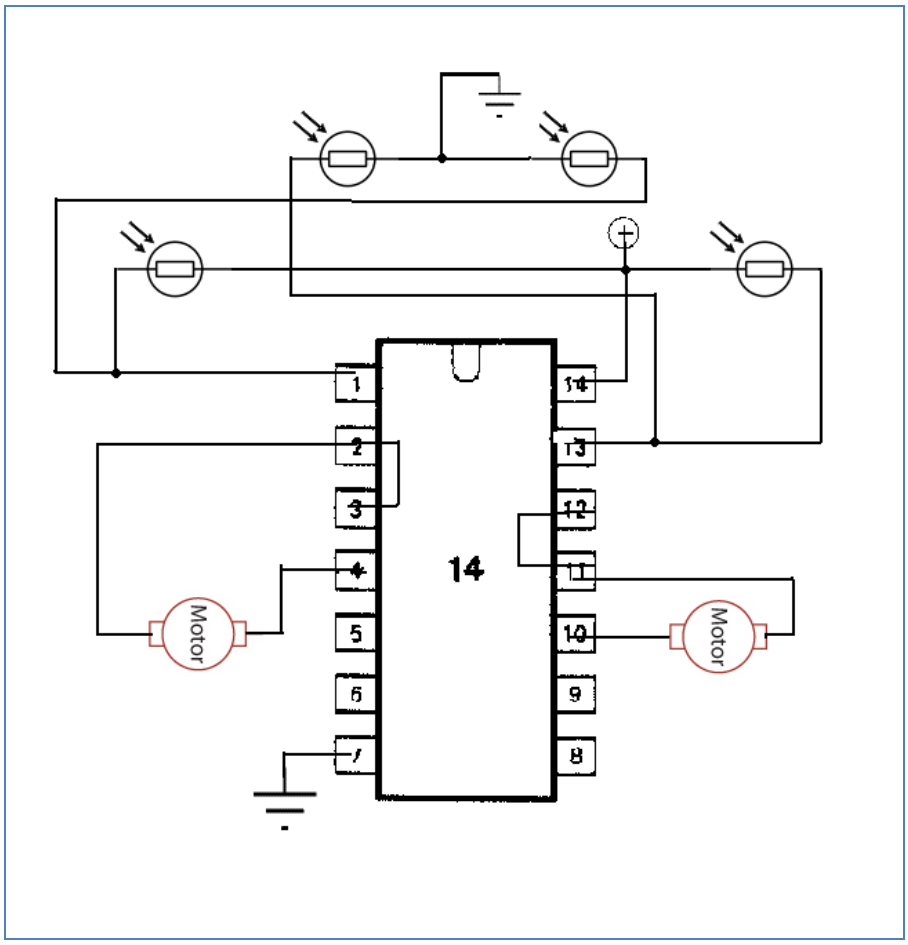
APPENDIX B

CIRCUIT P386



APPENDIX C

CIRCUIT P4LDR



APPENDIX D

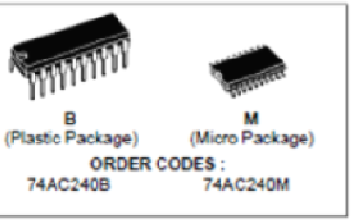
74AC240 DATASHEET

SGS-THOMSON MICROELECTRONICS

74AC240

OCTAL BUS BUFFER WITH 3 STATE OUTPUTS (INVERTED)

- HIGH SPEED: t_{PD} = 4 ns (TYP.) at V_{CC} = 5V
- LOW POWER DISSIPATION: I_{CC} = 8 µA (MAX.) at T_A = 25 °C
- HIGH NOISE IMMUNITY: $V_{NIH} = V_{NIL}$ = 28% V_{CC} (MIN.)
- 50Ω TRANSMISSION LINE DRIVING CAPABILITY
- SYMMETRICAL OUTPUT IMPEDANCE: $|I_{OH}| = I_{OL}$ = 24 mA (MIN)
- BALANCED PROPAGATION DELAYS: $t_{PLH} = t_{PHL}$
- OPERATING VOLTAGE RANGE: V_{CC} (OPR) = 2V to 6V
- PIN AND FUNCTION COMPATIBLE WITH 74 SERIES 240
- IMPROVED LATCH-UP IMMUNITY



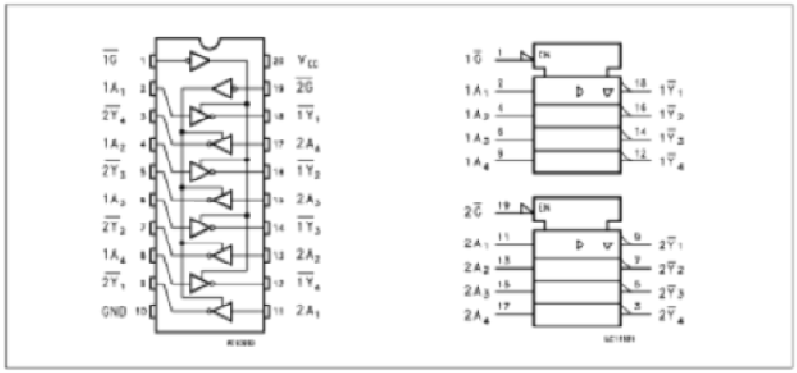
B (Plastic Package) M (Micro Package)

ORDER CODES :
74AC240B 74AC240M

DESCRIPTION

The AC240 is an advanced CMOS OCTAL BUS BUFFER (3-STATE) fabricated with sub-micron silicon gate and double-layer metal wiring C²MOS technology. It is ideal for low power applications mantaining high speed operation similar to equivalent Bipolar Schottky TTL.
G control output governs four BUS BUFFERs.
This device is designed to be used with 3 state memory address drivers, etc.
All inputs and outputs are equipped with protection circuits against static discharge, giving them 2KV ESD immunity and transient excess voltage.

PIN CONNECTION AND IEC LOGIC SYMBOLS



APPENDIX E

NE555N DATASHEET

NE555
SA555 - SE555

GENERAL PURPOSE SINGLE BIPOLAR TIMERS

- LOW TURN OFF TIME
- MAXIMUM OPERATING FREQUENCY GREATER THAN 500kHz
- TIMING FROM MICROSECONDS TO HOURS
- OPERATES IN BOTH ASTABLE AND MONOSTABLE MODES
- HIGH OUTPUT CURRENT CAN SOURCE OR SINK 200mA
- ADJUSTABLE DUTY CYCLE
- TTL COMPATIBLE
- TEMPERATURE STABILITY OF 0.005% PER°C

N
DIP8
(Plastic Package)

D
SO8
(Plastic Micropackage)

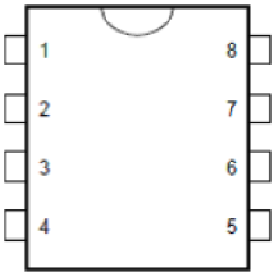
DESCRIPTION

The NE555 monolithic timing circuit is a highly stable controller capable of producing accurate time delays or oscillation. In the time delay mode of operation, the time is precisely controlled by one external resistor and capacitor. For a stable operation as an oscillator, the free running frequency and the duty cycle are both accurately controlled with two external resistors and one capacitor. The circuit may be triggered and reset on falling waveforms, and the output structure can source or sink up to 200mA. The NE555 is available in plastic and ceramic minidip package and in a 8-lead micropackage and in metal can package version.

ORDER CODES

Part Number	Temperature Range	Package	
		N	D
NE555	0°C, 70°C	•	•
SA555	–40°C, 105°C	•	•
SE555	–55°C, 125°C	•	•

PIN CONNECTIONS (top view)



1 - GND
2 - Trigger
3 - Output
4 - Reset
5 - Control voltage
6 - Threshold
7 - Discharge
8 - Vcc

APPENDIX F

LM386 DATASHEET

National Semiconductor

August 2000

LM386
Low Voltage Audio Power Amplifier

General Description

The LM386 is a power amplifier designed for use in low voltage consumer applications. The gain is internally set to 20 to keep external part count low, but the addition of an external resistor and capacitor between pins 1 and 8 will increase the gain to any value from 20 to 200.

The inputs are ground referenced while the output automatically biases to one-half the supply voltage. The quiescent power drain is only 24 milliwatts when operating from a 6 volt supply, making the LM386 ideal for battery operation.

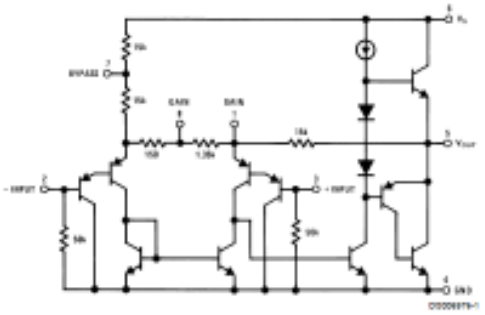
Features

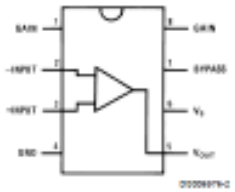
- Battery operation
- Minimum external parts
- Wide supply voltage range: 4V–12V or 5V–18V
- Low quiescent current drain: 4mA
- Voltage gains from 20 to 200
- Ground referenced input
- Self-centering output quiescent voltage
- Low distortion: 0.2% (A_V = 20, V_S = 6V, R_L = 8Ω, P_O = 125mW, f = 1kHz)
- Available in 8 pin MSOP package

Applications

- AM-FM radio amplifiers
- Portable tape player amplifiers
- Intercoms
- TV sound systems
- Line drivers
- Ultrasonic drivers
- Small servo drivers
- Power converters

Equivalent Schematic and Connection Diagrams





Small Outline, Molded Mini Small Outline, and Dual-In-Line Packages

Top View
Order Number LM386M-1, LM386MM-1, LM386N-1, LM386N-3 or LM386N-4
See NS Package Number M08A, MUA08A or N08E

 DS006976

APPENDIX G

74HC14 DATASHEET

Hex inverting Schmitt trigger 74HC/HCT14

PIN DESCRIPTION

PIN NO.	SYMBOL	NAME AND FUNCTION
1, 3, 5, 9, 11, 13	1A to 6A	data inputs
2, 4, 6, 8, 10, 12	1Y to 6Y	data outputs
7	GND	ground (0 V)
14	V_{CC}	positive supply voltage

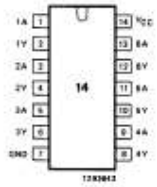


Fig.1 Pin configuration.

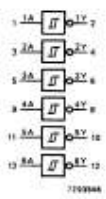


Fig.2 Logic symbol.

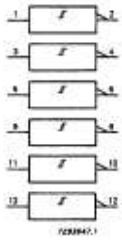


Fig.3 IEC logic symbol.

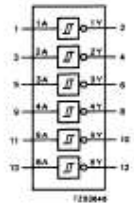


Fig.4 Functional diagram.

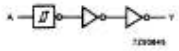


Fig.5 Logic diagram (one Schmitt trigger).

FUNCTION TABLE

INPUT	OUTPUT
nA	nY
L	H
H	L

Notes

1. H = HIGH voltage level
   L = LOW voltage level

APPLICATIONS

- Wave and pulse shapers
- Astable multivibrators
- Monostable multivibrators