A Report on the Project

Versatile Torso Pro-Bot

Submitted by

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ABSTRACT

Abstract: There are several reasons to build a robot with humanoid form. It has been argued that to build a machine with human like intelligence, it must be embodied in a human like body. Others argue that for humans to interact naturally with a robot, it will be easier for the humans if that robot has humanoid form. A third, and perhaps more concrete, reasons for building a humanoid robot is to develop a machine that interacts naturally with human spaces; with the simpler versions of the humanoid turning out to be Torso robots or wheeled robots.

The report presents one such technique to design the torso robot. The Programmable Robot (Pro-Bot) has the ability to move forward and backward, left & right and to grip objects. The feature making the robot versatile is the adaptation to different modes of navigation techniques such as line following, wireless control and using programmed sequence.

CERTIFICATE

This is to certify that Ramniklal J. Mota, Rakeshsingh B. Rana, Nikhit B. Sankhe, Amar M. Verma are the bonafide students of St. Francis Institute of Technology, Mumbai. They have successfully carried out the project titled 'Versatile Torso Pro-Bot' in partial fulfillment of the requirement of B. E. Degree in Electronics and Telecommunication Engineering of Mumbai University during the academic year 2011-2012. The work has not been presented elsewhere for the award of any other degree or diploma prior to this.

( ) **Internal Guide**	**( )** **External Guide**
( ) **Internal Examiner**	**( )** **External Examiner**
(Dr T S Rathore) **HOD**	**(Dr A K Sen)** **Principal**

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In the next paragraph you may extend thanks to other colleagues in the department whom you might have approached for academic help with regard to your project.

We are also highly grateful to Dr T S Rathore Head of Department (EXTC), and Principal Dr A K Sen and the Director Bro Melchior Tom for providing the facilities, a conducive environment and encouragement.

Signatures of all the students in the group

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(Nikhit B. Sankhe)

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CONTENTS

List of Abbreviations

DOF	Degree of Freedom
RF	Radio Frequency
ANT	Antenna
PWM	Pulse Width Modulation
GND	Ground
FET	Field Effect Transistor
MOSFET	Metal-Oxide Semiconductor FET
IC	Integrated Circuit
API	Application Programming Interface
PCB	Printed Circuit Board
DC	Direct Current
AVR	Alf (Egil Bogen) and Vegard (Wollan)'s Risc processor

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Chapter 1

Introduction

Modern humanoids have major subsystems that can best be defined as their lower and upper bodies. The lower bodies are legs, wheels, or tracks that provide locomotion for propelling the upper body through a workspace. The upper bodies are arms, hands and heads, able to interact with the environment and perform work. The junction of these segments is a torso, which typically carries energy storage and computers for control.

1.1 Versatile Torso Pro-Bot : 'NARR'

Versatile Torso Pro-Bot is a project to design robot which can be controlled through an Embedded Program; hence the name 'Pro-Bot'- Programmable Robot. Trunk or torso is an anatomical term for the central part of the many animal bodies (including that of the human) from which extend the neck and limbs.

A Torso robot is a Human like structure consisting of upper torso, head, arms and navigational wheels. The Torso robot is named '*NARR*' after its developer's viz., *Nikhit, Amar, Rakesh & Ramnik* respectively. Fig 1.1 shows the actual robot developed.

The Following table summarizes the specification of the robot.

Parameter	**Description**
Name	Versatile Torso Pro-Bot : 'NARR'
Height	72 cms
Weight	5 kg
DOF	7 DOF
Actuators	VTS-08B, VTS-10A, NRS-585
Controller Board	Atmel Atmega 128
Power	12V, 7.4Ah; 6V, 1.3Ah.
Sensors	Temperature, Alcohol, Ultrasonic
Communication	Radio Frequency (315Mhz)

Table 1.1: Robot specification

Different algorithms utilizing Line following, Obstacle detection, programmed sequence etc. forms the basis of its navigation making it versatile in terms of controls and movements.

The robot is articulated to be operating in 3 different modes as follows

1. Programming mode:
   In this mode, the Pro-Bot traverses a predefined path using an embedded program. This utilizes microcontroller AVR Atmega C program and dynamic input using optical and ultrasonic sensors.

2. RF Remote Control mode:
   Operating the robot using RF remote control to navigate in various directions and performing different tasks to pick, carry and place things from one location to another.

3. Data acquisitions of environmental parameters:
   This mode of operation is mainly used to measure various environmental parameters like Temperature, gases etc. using sensors. This requires calibration of various sensors and data transfer of measured parameters. This mode is an independent mode and can be operated with remaining two modes.

1.2 Motivation

The major objective behind designing a humanoid robot is to build a machine to assist humans in such tasks as operation of power plants, disaster relief, constructions and surveying unmanned locations.

The greatest motivation for development of the humanoid robot is the fascination. Human- appearing robots fascinates us for all sorts of reasons and similarly the biped robot developed by the students of BITS, Pilani called ‘‘AcYut - The Biped’’ (refer figure 1.2) motivated us to develop something of a similar kind and ultimately led to the development of a Torso Robot – NARR!

[http://www.acyut.com/web/webpages/index.php?page=robots&tab=acyutbiped]

Fig. 1.1: Final Torso Pro-Bot: NARR

Fig. 1.2: BITS Pilani’s AcYut – The Biped

Chapter 2

Literature Survey

2.1 Robot

A robot is a mechanical or virtual intelligent agent that can perform tasks automatically or with guidance, typically by remote control. In practice a robot is usually an electro-mechanical machine that is guided by computer and electronic programming. Robots can be autonomous, semi-autonomous or remotely controlled.

The word robot can refer to both physical robots and virtual software agents, but the latter are usually referred to as bots. There is no consensus on which machines qualify as robots but there is general agreement among experts, and the public, that robots tend to do some or all of the following: move around, operate a mechanical limb, sense and manipulate their environment, and exhibit intelligent behavior — especially behavior which mimics humans or other animals. **[http://en.wikipedia.org/wiki/Robot]**

Robots may come in different shapes — one may look like a simple machine, an animal, or may appear in human form. A robot which has a human-like appearance is called a humanoid robot. When a humanoid robot is covered with a human-like skin and looks exactly like a human being, it is called an android (robot in male form) or gynoid (robot in female form). **[http://rationalwiki.org/wiki/Robot]**

Robotics is, to a very large extent, all about system integration, achieving a task by an actuated mechanical device, via an "intelligent" integration of components, many of which it shares with other domains, such as systems and control, computer science, character animation, machine design, computer vision, artificial intelligence, cognitive science, biomechanics, etc. In addition, the boundaries of robotics cannot be clearly defined, since also its "core" ideas, concepts and algorithms are being applied in an ever increasing number of "external" applications, and, vice versa, core technology from other domains (vision, biology, cognitive science or biomechanics, for example) are becoming crucial components in more and more modern robotic systems.
[**http://www.electronicsteacher.com/robotics/]**

2.2 Types of Robots

Robots do a lot of different tasks in many fields and the number of jobs entrusted to robots is growing steadily. So the best way to divide robots into types is a division by their application and by their type of locomotion. Refer figure 2.1.
[http://www.allonrobots.com/types-of-robots.html]

a) Types of Robots based on the applications:

1. <u>Industrial robots</u> - Industrial robots are robots used in an industrial manufacturing environment. Usually these are articulated arms specifically developed for such applications as welding, material handling, painting and others.

2. Domestic or household robots - Robots used at home. This type of robots includes many different devices such as robotic vacuum cleaners, robotic pool cleaners, sweepers, gutter cleaners and other robots that can do different chores. Also, some surveillance and tele-presence robots could be regarded as household robots if used in that environment.

3. Medical robots - Robots used in medicine and medical institutions. First and foremost - surgery robots. Also, some automated guided vehicles and maybe lifting aides.

4. Military robots - Robots used in military. This type of robots includes bomb disposal robots, different transportation robots, reconnaissance drones. Often robots initially created for military purposes can be used in law enforcement, search and rescue and other related fields.

5. Space robots - This type would include robots used on the International Space Station, Canada that was used in Shuttles, as well as Mars rovers and other robots used in space.

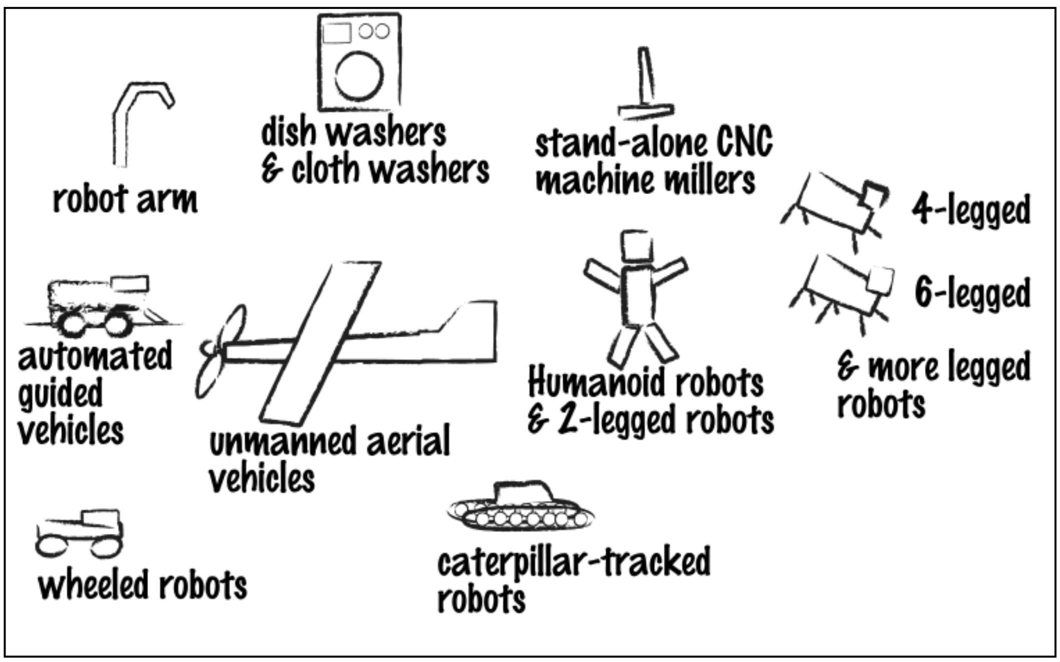


Fig. 2.1: Types of Robots

b) Types of Robots based on the locomotion:

1. Stationary robots (including robotic arms with a global axis of movement) -
   1.1 Cartesian/Gantry robots
   1.2 Cylindrical robots
   1.3 Spherical robots
   1.4 SCARA robots
   1.5 Articulated robots (robotic arms)
   1.6 Parallel robots

2. Wheeled robots –
    2.1 Single wheel (ball) robots
    2.2 Two-wheel robots
    2.3 Three and more wheel robots
    2.4 Upper Torso wheel robots

3. Legged robots –
    3.1 Bipedal robots (humanoid robots)
    3.2 Tripped robots
    3.3 Quadruped robots
    3.4 Hexapod robots

4. Flying robots

5. Mobile Spherical Robots

6. Swarm robots

2.3 Humanoids

Humanoid robots, robots with an anthropomorphic body plan and human-like senses, are enjoying increasing popularity as research tool. More and more groups, worldwide, work on issues like bipedal locomotion, dexterous manipulation, audio-visual perception, human-robot interaction, adaptive control, and learning, targeted for the application in humanoid robots. These efforts are motivated by the vision to create a new kind of tool: robots that work in close cooperation with humans in the same environment that we designed to suit our needs. While highly specialized industrial robots are successfully employed in industrial mass production, these new applications require a different approach: general purpose humanoid robots.
[**http://en.wikipedia.org/wiki/Humanoid_robot]**
A humanoid robot is a robot that is based on the general structure of a human, such as a robot that walks on two legs and has an upper torso, or a robot that has two arms, two legs and a head. A humanoid robot does not necessarily look convincingly like a real person, for example the ASIMO humanoid robot has a helmet instead of a face.
An android (male) or gynoid (female) is a humanoid robot designed to look as much like a real person as possible, although these words are frequently perceived to be synonymous with humanoid.
While there are many humanoid robots in fictional stories, some real humanoid robots have been developed since the 1990s, and some real human-looking android robots have been developed since 2002.
The human body is well suited for acting in our everyday environments. Stairs, door, handles, tools, and so on are designed to be used by humans. A robot with a human-like body can take advantage of these human-centered designs. The new applications will require social interaction between humans and robots. If a robot is able to analyze and synthesize speech, eye movements, mimics, gestures, and body language, it will be capable of intuitive communication with humans. Most of these modalities require a human-like body plan. A human-like action repertoire also facilitates the programming of

the robots by demonstration and the learning of new skills by imitation of humans, because there is a one-to-one mapping of human actions to robot actions.
Last, but not least, humanoid robots are used as a tool to understand human intelligence. In the same way biometric robots have been built to understand certain aspects of animal intelligence, humanoid robots can be used to test models of aspects of human intelligence.

Few of the humanoids developed by the well known brands in the world are as follows:

1. QRIO

Made by: Sony
Height: 61cm
''Quest for cu**rio**sity", originally named Sony Dream Robot or SDR. Refer figure 2.2.
Purpose: To live with you, make life fun and make you happy.
What can it do: Walk, talk, run, dance, recognize voices and faces, play ball games and surf the web.

Features:

i. Foot sensors so it can play soccer.
ii. Ankles with ball joints so it can walk on uneven surfaces.
iii. Picks itself up after falling and even checks itself for damage.
iv. Moves with quick, smooth movements.

Fig. 2.2: QRIO

2. ASIMO

Made by: Honda
Height: 1.2m
ASIMO stands for: Advanced Step in Innovative Mobility, it also takes its name from robotic visionary Isaac Asimov. Refer figure 2.3.
Purpose: Began in 1986 as a study into human movement and has since evolved into a robot capable of a wide range of tasks.
What can it do: It can walk, run, turn corners, recognize hand gestures, carry objects, dance and climb up and down stairs.

Features:

i. May be the most advanced humanoid robot in the world.
ii. Can perform simple tasks, such as switching on a light switch.

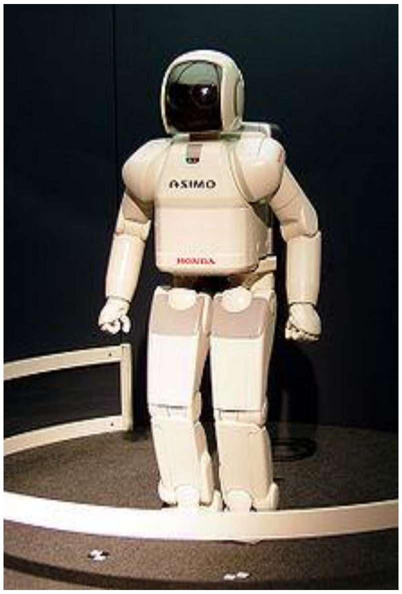


Fig. 2.3: ASIMO

3. AIBO
Made by: Sony (Japan)
Height: 27cm
AIBO stands for: Artificial Intelligent Robot

AIBO features a variety of senses:

i. Touch - Feels human contact through sensors on head, back, chin & paws.
ii. Hearing - Detects sound through a pair of stereo microphones, voice recognition.
iii. Sight - Color camera, distance sensors and facial recognition.
iv. Balance - Keeps balance through acceleration sensors.


Fig. 2.4: AIBO

2.4 Torso Robots

Trunk or torso is an anatomical term for the central part of the many animal bodies (including that of the human) from which extend the neck and limbs. These forms of humanoids are very similar to the traditional form, differing only by the mode of navigation. Some trunks are attached to a stationary platform and some to an Omni-platform. Greater emphasis is laid on the design of the torso and the head movement along with the arms. The torsos attached to a wheeled platform has its navigation much simpler compared to the legged robots.

Few of the well-known torso robots are as follows:

1. NASA Robonaut: [http://www.nasa.gov/audience/forstudents/5-8/features/what-is-robonaut-58.html]

Robonaut is a humanoid robotic development project conducted by the Dexterous Robotics Laboratory at NASA's Johnson Space Center (JSC) in Houston, Texas. Robonaut differs from other current space-faring robots in that, while most current space robotic systems (such as robotic arms, cranes and exploration rovers) are designed to move large objects, Robonaut's tasks require more dexterity.

The core idea behind the Robonaut series is to have a humanoid machine work alongside astronauts. Its form factor and dexterity are designed such that Robonaut can use space tools and work in similar environments suited to astronauts.

Robonaut can function in two ways. Software allows Robonaut to "think" for itself. The people who control R2 can give it a simple task to do and R2 can figure out how to do it. R2's software can be updated to allow it to do new tasks. R2 also can be operated by remote control. An operator can use a headset to see what Robonaut sees through its cameras. The operator can then use controls to make Robonaut move.

Fig. 2.5: NASA Robonaut

2. PaPeRo

<u>Made by:</u> NEC
<u>Height:</u> 38cm
PaPeRo stands for: **Pa**rtner-type **Pe**rsonal **Ro**bot. *Refer figure 2.6.*
<u>Purpose:</u> To both entertain and assist around the house.
<u>What can it do:</u> Recognizes speech, talks, moves, responds to users, controls household devices.

Fig. 2.6: PaPeRo

Features:

i. Can wirelessly control your TV and surf the internet.
ii. Designed to look cute so humans feel protective rather than threatened.
iii. Recognizes 650 phrases and 3000 words.

3. Dexterous Torso

The Dexterous Torso, designed by Energid in collaboration with Cinvestav, is a humanoid torso with two hands, a waist, and independently directed camera eyes. With two three-fingered hands, it can lift 400 grams in cooperative actions.
With two additional degrees of freedom at the waist, the torso has the property of redundancy and bifurcation which enables placement of either hand at a desired position and orientation within its workspace in an unlimited number of ways.
Mechanical Structure: 24 DOF including two four-DOF grippers, two five-DOF arms, a four-DOF head, and a two-DOF waist. All arm axes can be controlled simultaneously.

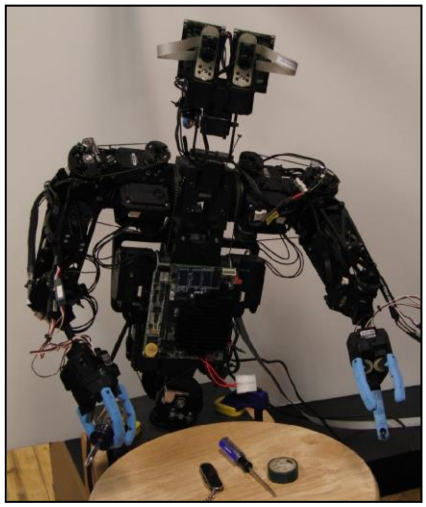


Fig. 2.7: Dexterous Torso

[http://mekabot.com/products/humanoid-torso/]
4. Meka T2 Humanoid Torso

The Meka T2 Humanoid Torso is a two degree-of-freedom force controlled torso for a humanoid robot. It is design to increase the workspace of a Meka A2 bimanual manipulator system. Engineered for stability, safety, and reliability, the T2 system features high-strength force-controlled actuators, zero-backlash Harmonic Drive gear heads, integrated brake, and the Meka M3 real-time control system. The T2 has two pitch joints that are mechanically coupled 1:1 and driven by a single actuator. This enables natural motions as the torso leans forward and increases the torso workspace while keeping the center-of-gravity close in.

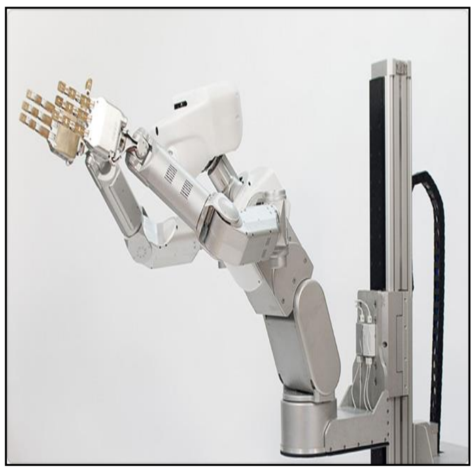


Fig. 2.8: Meka T2 Humanoid Torso

Chapter 3

Robot design

3.1 Mechanical

The project – NARR was fabricated by the group members themselves. As per the dimensions, the Robot's height is **72 cms** and it weighs almost **5kg - 6kg** inclusive of on-board battery. The robot features 7 DOF in all with 3 DOF in each arm and 1 for the neck joint. The Google sketch up design of the robot is shown in the figure 3.1, which underwent many changes at every stage to develop an aesthetic and a working robot. The final developed robot is shown in the *figure 3.2.*

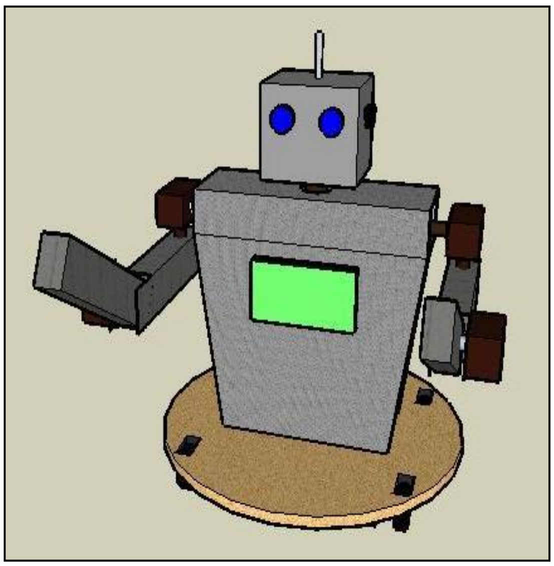


Fig. 3.1: Google sketch-up design

Fig. 3.2: Final developed design

The mechanical aspect of the robot can be best understood by classifying it further down to its basic components such as upper limbs, trunk, face and the navigational platform.

1. **Upper Limbs**

The arms of the robot provides with 6 DOF in all. Each arm is fabricated using aluminium L and the servo brackets. The total length of the limb, when stretched, is **x cms** *(refer fig 3.3).* Movement of the arm is characterized by various joints obtained by configuring the servo motors in a particular fashion. Entire arm was fabricated in four different parts as shoulder joint, arm, elbow joint and the end effectors (or the hand).

a. <u>Shoulder joint:</u> The foremost joint in the upper limb was fabricated using 2 servo motors. The motors employed for this function were high torque servos with metal gears. *Figure 3.4* shows the assembly of the servo motors to obtain the desired joint. The 1st servo motor is connected over the trunk. The 2nd motor is attached over the spline of the 1st motor using the servo bracket. This position of the motors allows movement in two orthogonal planes thus providing with 2 DOF for the limb.

Fig. 3.3: Upper Limb

Fig. 3.4: Shoulder joint

b. Arm: The region between the shoulder and the elbow is the arm of the robot. It is completely fabricated using 2 aluminium L strips. Each strip is connected to the servo bracket over the spline of the second servo of the shoulder joint. The arm forms the supporting link for the elbow joint. The total length of the upper arm is **y cms.** *Refer figure 3.5.*

Fig. 3.5: Arm

c. Elbow joint: The Lower most joint in the limb, elbow joint, is used to provide movement for the end effectors. The joint was realized using a servo motor relatively of lower torque rating compared to the motors used for shoulder joint. *Refer figure 3.3.* The motor is connected on the supporting link. The spline of this joint provides connection for the end effectors.

d. End Effectors: An end effector is the device at the end of a robotic arm, designed to interact with the environment. End effectors may consist of a gripper or a tool. The exact nature of this device depends on the application of the robot. The end effector in our design is extended from the elbow joint. It is made from an aluminium box with cross sectional area of 1’ X 2’ *(refer figure 3.3)*. A flat plate like structure is used to terminate the structure which assists the arm in gripping the objects.

2. **Trunk (or Torso)**

Trunk or the Torso forms the main body part of the robot. The structure is erected using Medium Density Fiber-board (MDF) and supporting aluminium strips. Medium-density fiberboard (MDF) is an engineered wood product formed by breaking down hardwood or softwood residuals into wood fibers, often in a defibrator, combining it with wax and a resin binder, and forming panels by applying high temperature and pressure. The main

reason behind using MDF is to reduce the overall weight of the robot. It is stronger and much denser than normal particle board. Most important circuits are housed within the torso. The robot design is a product based design and so the circuit boards are incorporated on a hinged window, forming back of the robot.
Two LCDs viz., 20*4 and 16*2 are connected over the chest region to display the output data. The entire torso is placed over the Omni-platform. *Refer figure 3.6.*

Fig. 3.6: Torso

Fig.3.7: Face

3. **Face**

To provide with the human appearance *(refer figure 3.7)*, the sensors are embodied on the acrylic piece of dimension x*y cm forming the face of the robot. Ultrasonic sensors are used to works as vision sensors and gas sensor to detect presence of gas. Besides this, two temperature sensors are also fitted on the face. Entire face is connected on the spline of the servo motor, which is used as a neck joint.

4. **Omni-Platform**

The Most important part of the robot is its platform. The Omni-platform differentiates it with the traditional humanoids. The Biped legs are being replaced by four omni directional wheels. *Figure 3.8* shows the type of the omni wheel used for the project. The Omni wheels make it possible for the robot to move in two orthogonal axes without taking a turn.
Two acrylic sheet of dimension 12.5’ x 12.5’ are used as the platform, which are separated by a distance of 14cm with help of 6 metal stud bolts. Motors and batteries are placed between these sheets. The platform also provides with the main power switch and charging ports for the battery. *Refer figure 3.9.*

Fig. 3.8: Omni wheels

Fig. 3.9: Omni platform

3.2 Electronics

The Versatile Torso Pro-Bot is a complex system employing many different circuitries for varied blocks. Sensors to motors, all are driven by different driver circuits which are all controlled by the main controller Atmega128. The electronics section can be divided into various blocks as follows:

i. Mother Board (or Controller)
ii. Power Board
iii. Motor driver
iv. Servo and Base Motors
v. Sensors
vi. LCD

1. **Mother Board**

A microcontroller often serves as the ‘brain’ of a mechatronic system [10]. Like a mini, self-contained computer, it can be programmed to interact with both the hardware of the system and the user. The controller used for the robot is Atmel’s Atmega128 as shown in the *figure 3.10*. The controller being a SMD, a socket of the controller was used. *Refer figure 3.11.* The socket provided with the operating crystal of 11.0486*** Mhz, reset button and the programming connector. This socket is mounted on general purpose PCB using berg strip connector.

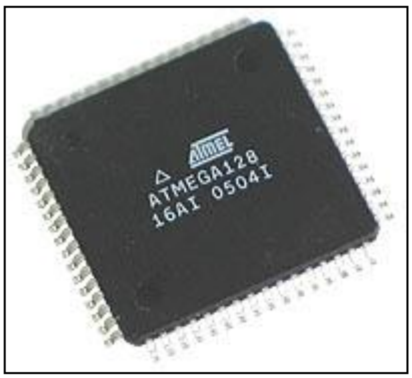


Fig.3.10: Atmega128 SMD

Fig.3.11: Atmega128 socket

Salient Features of Atmega128 are:

i. Advanced RISC Architecture
ii. Up to 16 MIPS Throughput at 16 MHz
iii. 128K Bytes of In-System Reprogrammable Flash
iv. In-System Programming by On-chip Boot Program
v. 4K Bytes EEPROM
vi. 4K Bytes Internal SRAM
vii. 8-channel, 10-bit ADC
viii. 7 Differential Channels
ix. Two 8-bit Timer/Counters with Separate Prescaler and Compare Modes
x. Two 16-bit Timer/Counters with Separate Prescaler, Compare Mode & Capture Mode
xi. Real Time Counter with Separate Oscillator
xii. Two 8-bit PWM Channels

xiii. 6 PWM Channels with Programmable Resolution from 2 to 16 Bits
xiv. Output Compare Modulator
xv. Byte-oriented Two-wire Serial Interface
xvi. Dual Programmable Serial USARTs
xvii. Master/Slave SPI Serial Interface
xviii. Programmable Watchdog Timer with On-chip Oscillator
xix. On-chip Analog Comparator

2. **Power Board**

The presence of hard drive components such as servo motors, DC motors and LCDs require higher current and appropriate voltages. The entire system is amalgamation of circuits requiring either 5V or 12V and servo motors asking for 6V (at different current ratings). So it becomes very essential to make a power board fulfilling needs of all circuits. Based on this two different power boards were made. One of the power boards is exclusively used for servo motors providing 6V at 1.3Ah (max) and other power board for rest of the circuits. The second power board has a power regulator L7805 to provide 5V at the output.

Extension boards, *as shown in the figure 3.12*, are used to provide power to servo motors located at the joints.

Fig. 3.12: Extension Board

3. **Motor Driver**

Generally an IC cannot pass enough current or voltage to spin a motor. Also, motors tend to be electrically noisy (spikes) and can slam power back into the control lines when the motor direction or speed is changed. Motor Driver Circuits supply motors with power and to isolate the other ICs from electrical problems. These circuits can be designed such that they can be completely separate boards, reusable from project to project.

A very popular circuit for driving DC motors (ordinary or gear head) is called an H-bridge. It's called that because it looks like the capital letter 'H' when viewed on a discrete schematic. The great ability of an H-bridge circuit is that the motor can be driven forward or backward at any speed, optionally using a completely independent power source. An H-bridge can be implemented with various kinds of components (common Bipolar Junction Transistors, MOSFETs Transistors or Power MOSFETs)

Four H-bridge circuits were used to drive the navigational DC motors.

Fig. 3.13: H- bridge circuit

The circuit used features:

i. 1 Motor Channel
ii. 5.5VDC-30VDC operating voltage
iii. 7A continuous output current per channel
iv. 10A peak output current per channel

4. **Servo And DC Motors**

A Servo refers to an error sensing feedback control which is used to correct the performance of a system. Servo or RC Servo Motors are DC motors equipped with a servo mechanism for precise control of angular position. The RC servo motors usually have a rotation limit from 90° to 180°.

The servo motor can be moved to a desired angular position by sending PWM (pulse width modulated) signals on the control wire. *Refer Figure 3.14, 3.15 & 3.16.*

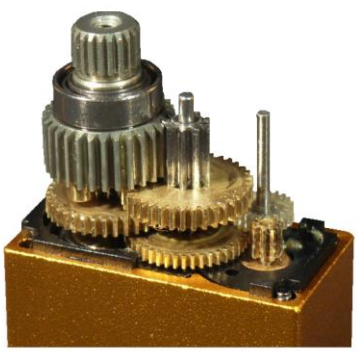


Fig. 3.14: Metal Gear Servo

Fig. 3.15: VTS-08B Servo

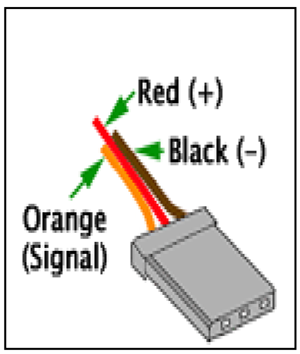


Fig. 3.16: Servo wire code

A DC motor is an electric motor that runs on direct current (DC) electricity. Several characteristics are important in selecting a DC motor; they are operating voltage, operating current, speed, torque and power. The motors used for navigation in the project are of following specifications: speed- 200rpm, torque - 12kg at Operating Voltage- 12V. *Refer Figure 3.17.*

Fig. 3.17: High Torque DC motor

5**. Sensors**

A sensor is an electronic device that transfers a physical phenomenon (temperature, pressure, gas, humidity, etc.) into an electrical signal. Sensors in Robotics are used for both internal feedback control and external interaction with the outside environment [13].

<u>1. Temperature sensor – LM35:</u>

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ˚F Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. *Refer figure 3.18* for different packages available.

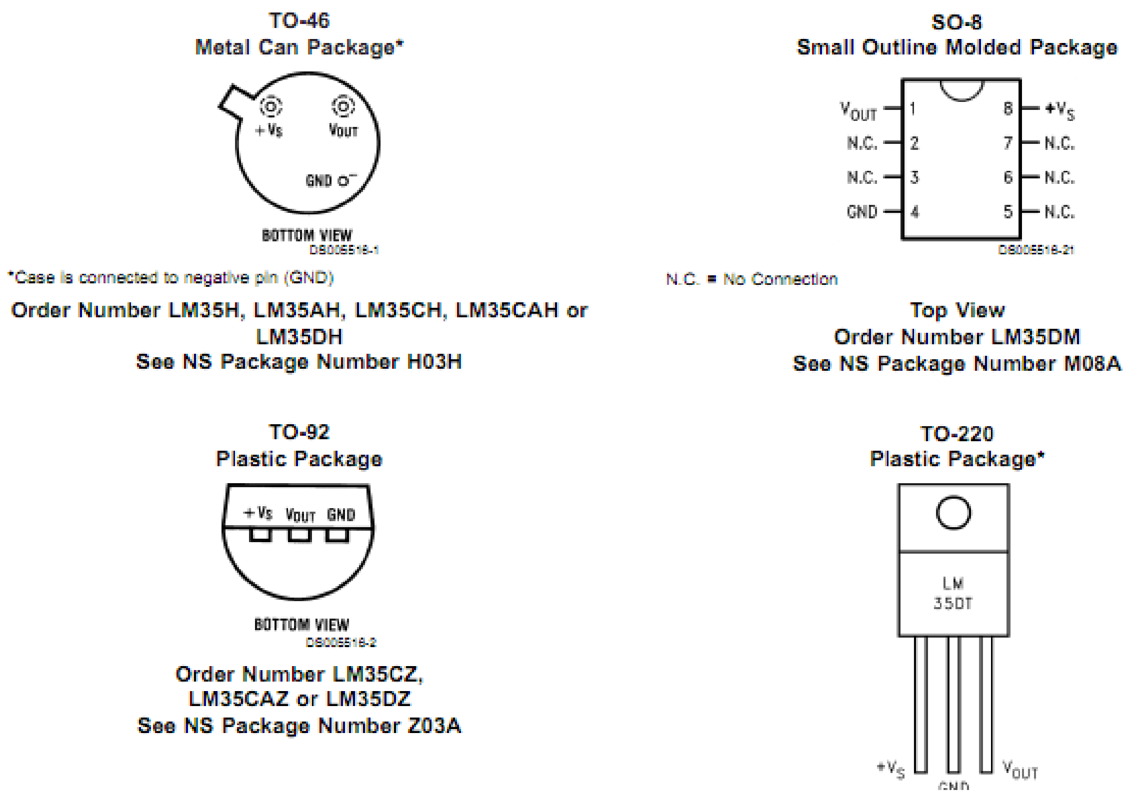


Fig. 3.18: Different LM35 IC packages

Features:

1. Calibrated directly in ˚ Celsius (Centigrade)
2. Linear + 10.0 mV/˚C scale factor
3. 0.5˚C accuracy guarantee able (at +25˚C)
4. Rated for full −55˚ to +150˚C range
5. Suitable for remote applications
6. Low cost due to wafer-level trimming
7. Operates from 4 to 30 volts
8. Less than 60 µA current drain

9. Low self-heating, 0.08˚C in still air
10. Low impedance output, 0.1 Ω for 1 mA load

2. Alcohol Sensor

The C2H5OH (Alcohol / Benzine) Gas Sensor Module (*Refer figure 3.19*) is designed to allow a microcontroller to determine when a preset C2H5OH gas level has been reached or exceeded. Interfacing with the sensor module is done through a 4-pin SIP header and requires two I/O pins from the host microcontroller. The sensor module is mainly intended to provide a means of comparing alcohol sources and being able to set an alarm limit when the source becomes excessive [10].

Fig. 3.19: Alcohol Sensor

Features:
1. Uses the MQ-3 C2H5OH Gas Sensor
2. Easy SIP interface
3. Compatible with most microcontrollers

3. Ultra Sonic Sensor:

Ultrasonic sensor provides a very low-cost and easy method of distance measurement.[12] *Refer figure 3.20*. This sensor is perfect for any number of applications that require you to perform measurements between moving or stationary objects. Naturally, robotics applications are very popular but you'll also find this product to be useful in security systems or as an infrared replacement if so desired. The sensor measures distance using sonar; an ultrasonic (well above human hearing) pulse is transmitted from the unit and distance-to-target is determined by measuring the time required for the echo return. Output from the sensor is a variable-width pulse that corresponds to the distance to the target.

Features:
1. Provides precise, non-contact distance measurements within a 2 cm to 3 m range
2. Simple pulse in/pulse out communication
3. Narrow acceptance angle

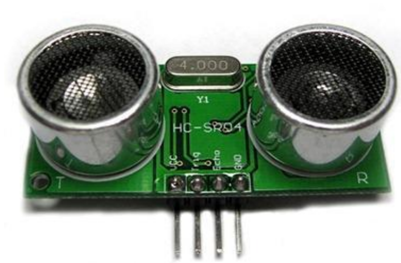


Fig 3.20: Ultrasonic Sensor

6**. Display Unit: LCD**

The 2 X16 Parallel LCD is an 8 bit or 4 bit parallel interfaced LCD. This unit allows the user to display text, numerical data and custom created characters. An LCD is a small low cost display. It is easy to interface with a micro-controller because of an embedded controller (the black blob on the back of the board).

Figure 3.21 shows a 20*4 LCD which is placed on the robots torso to display permanent data, whereas Figure 3.22 16*2 LCD is used to display temporary data and back hand calculations.

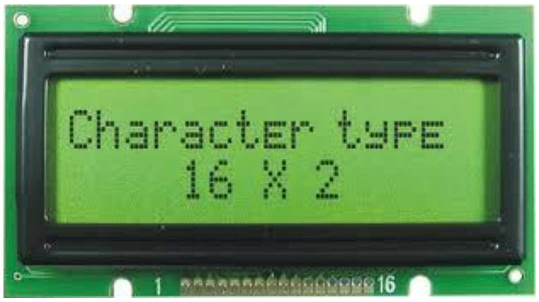


Fig. 3.21: LCD 16*2

Fig. 3.22: LCD 20*4

3.3 Communication

The RF module, as the name suggests, operates at Radio Frequency. The corresponding frequency range varies between 30 kHz & 300 GHz. In this RF system, the digital data is represented as variations in the amplitude of carrier wave. This kind of modulation is known as Amplitude Shift Keying (ASK)[12].

This RF module comprises of an RF Transmitter and an RF Receiver. The transmitter/receiver (Tx/Rx) pair operates at a frequency of 434 MHz/315MHz. The module used in the project is shown in the figure 3.23 & 3.24 Table 3.1 and 3.2 shows connection of various pins. An RF transmitter receives serial data and transmits it wirelessly through RF through its antenna connected at pin4. The transmission occurs at the rate of 1Kbps - 10Kbps. The transmitted data is received by an RF receiver operating at the same frequency as that of the transmitter.

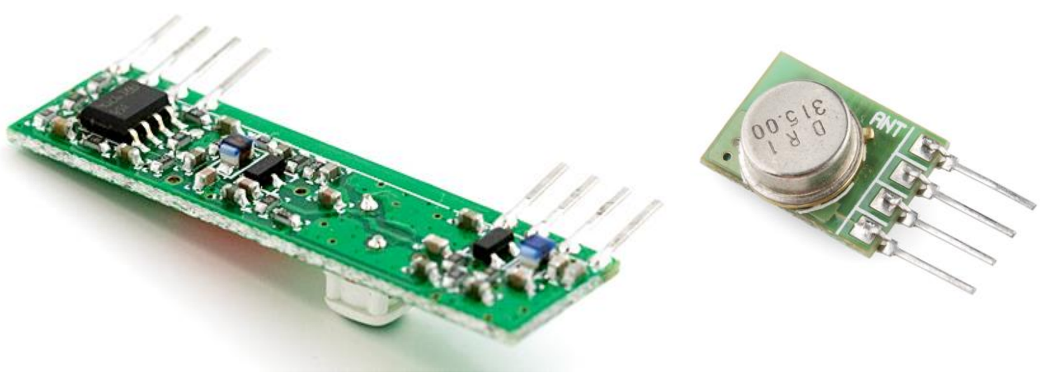


Fig. 3.23: RF Transmitter & Receiver

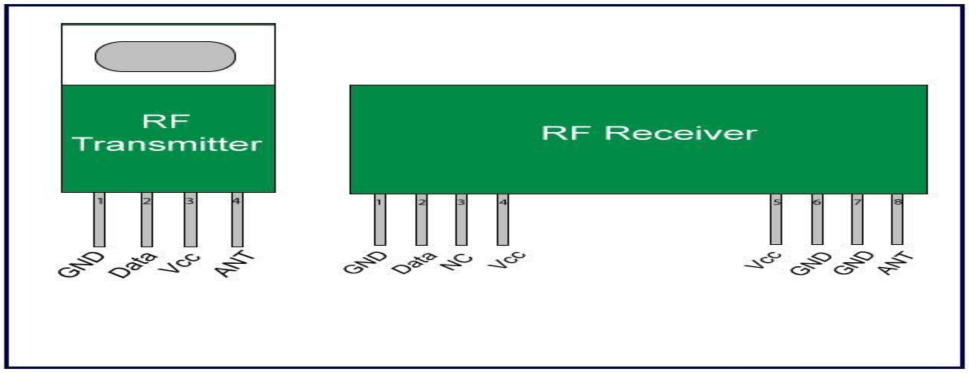


Fig. 3.24: RF module pinout

Table 2.1: RF Transmitter pin connections

Pin No.	Function	Name
1	Ground(0 V)	GND
2	Serial Input Data	Data
3	Supply Voltage (5 V)	Vcc
4	Antenna Output Pin	ANT

Table 2.2: RF Receiver pin connections

Pin No.	Function	Name
1	Ground (0 V)	GND
2	Serial Data Output	Data
3	Linear Output; Not Connected	NC
4	Supply Voltage (5 V)	Vcc
5	Supply Voltage (5 V)	Vcc
6	Ground (0 V)	GND
7	Ground (0 V)	GND
8	Antenna Input Pin	ANT

Chapter 3

Remote design

4.1 Design

The Torso Robot can be controlled via a RF remote. This remote was fabricated from a plastic box of dimension x*y cm. Figure 4.1 shows the designed remote.

Fig. 4.1: Transmitter remote

The remote incorporates a 4*4 Keypad, a 16*2 LCD, 4 potentiometer knobs and a power switch.

The communication between the remote and the robot takes place at a frequency of 315MHz. The remote is powered by a battery of 12V, 7Ah. The remote is provided with banana pin connectors, *as shown in the figure 4.2*, so that it can be directly plugged to a DC voltage regulator.

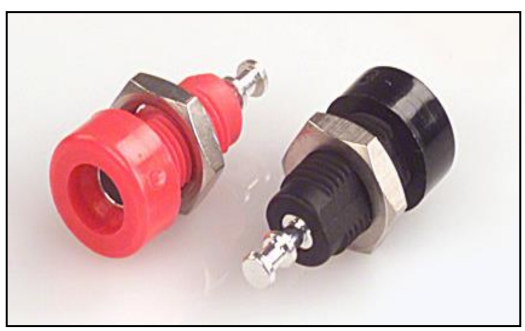


Fig. 4.2: Banana Female connector

4.2 Electronics

Various electronic components used in the remote are as follows:

1) **4*4 Matrix keypad:**

This 16-button keypad provides a useful human interface component for varied applications.

Fig. 4.3: 4*4 Matrix keypad

Key Specifications:

i. Maximum Rating: 24 VDC, 30 mA
ii. Interface: 8-pin access to 4x4 matrix
iii. Operating temperature: 32 to 122 °F (0 to 50°C)

The keypad has 3 permanent buttons for ‘N’, ‘H’, ‘S’ for three parameter modes Navigation, Hands and Sensors respectively. We can switch from one mode to another by directly pressing the required mode button. The remaining buttons varies in function with different modes. This keypad forms the main input source of the remote.

2) **Potentiometer Knobs:**

Potentiometers are used to actuate servo motors to appropriate angles. These potentiometers are provided with user friendly knob *(refer figure 4.3)* to set the pot to the desired angle value. The concept behind using the pot is to use the voltage division across the resistance. This voltage is then fed to the ADC and scaled accordingly to get the calibrated angles.

Fig. 4.3: Potentiometer

3 Knobs are used to actuate 3 different servo motors of the upper limbs. Right, Left or both the limbs can be selected during mode selection; and 1 knob is provided for the neck joint.

3) **20*4 LCD:**

The 20 X 4 Parallel LCD is an 8 bit or 4 bit parallel interfaced LCD. This unit allows the user to display text, numerical data and custom created characters. An LCD is a small low cost display. It is easy to interface with a micro-controller because of an embedded controller (the black blob on the back of the board).

Fig. 4.4: 20*4 LCD

Data received from the robot can be seen on the 20*4 LCD. It makes the User interface much simpler.

4) **Atmega 16:**

The brain of the remote is the Atmega 16. This controller is interfaced to various I/O and communication sections on the remote.

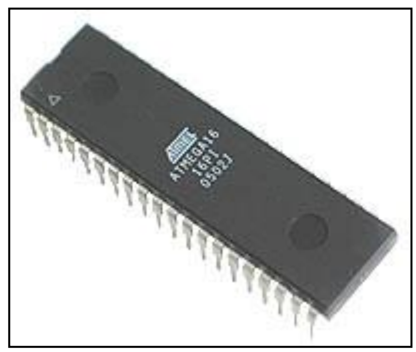


Fig. 4.5: Atmega 16

ATMEGA16 Microcontroller Features

i. Advanced RISC Architecture
ii. Up to 16 MIPS Throughput at 16 MHz
iii. 16K Bytes of In-System Self-Programmable Flash
iv. 512 Bytes EEPROM
v. 1K Byte Internal SRAM
vi. 32 Programmable I/O Lines
vii. In-System Programming by On-chip Boot Program
viii. 8-channel, 10-bit ADC
ix. 8 Single-ended Channels
x. 2 Differential Channels with Programmable Gain at 1x, 10x, or 200x
xi. Two 8-bit Timer/Counters with Separate Prescalers and Compare Modes
xii. One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture
xiii. Real Time Counter with Separate Oscillator
xiv. Four PWM Channels
xv. Programmable Serial USART
xvi. Master/Slave SPI Serial Interface
xvii. Byte-oriented Two-wire Serial Interface
xviii. Programmable Watchdog Timer with Separate On-chip Oscillator
xix. External and Internal Interrupt Sources
xx. 40-pin PDIP package

4.3 Communication

The RF module, as the name suggests, operates at Radio Frequency. The corresponding frequency range varies between 30 kHz & 300 GHz. In this RF system, the digital data is represented as variations in the amplitude of carrier wave. This kind of modulation is known as Amplitude Shift Keying (ASK) [12].

This RF module comprises of an RF Transmitter and an RF Receiver. The transmitter/receiver (Tx/Rx) pair operates at a frequency of 315MHz. The module used in the project is shown in the figure 2.2 and 2.3. Table 2.1 and 2.2 shows connection of various pins. An RF transmitter receives serial data and transmits it wirelessly through RF through its antenna connected at pin4. The transmission occurs at the rate of 1Kbps - 10Kbps. The transmitted data is received by an RF receiver operating at the same frequency as that of the transmitter.

Chapter 5

Project Design

5.1 Design Flow Chart

The design process of the project was, and indeed still is, an iterative one. Original specifications were very broad, and hence allowed a lot of scope during the design process. After research, it was possible to narrow down the problem statement to a very aesthetic model of the robot. This simulation then allowed refinement of the mechanical design, including selection of actuators and various sensors.

Initial step was Robot Designing with due consideration of all the different technologies which can be used. Based on the design, literature survey was carried out to check the availability of the different modules (technology/components) in the market. Before designing the electronics board for the robot various modules were implemented and tested on breadboard, followed by software programming of the controllers.

The flowchart shown in figure 3.1 summarizes the design process.

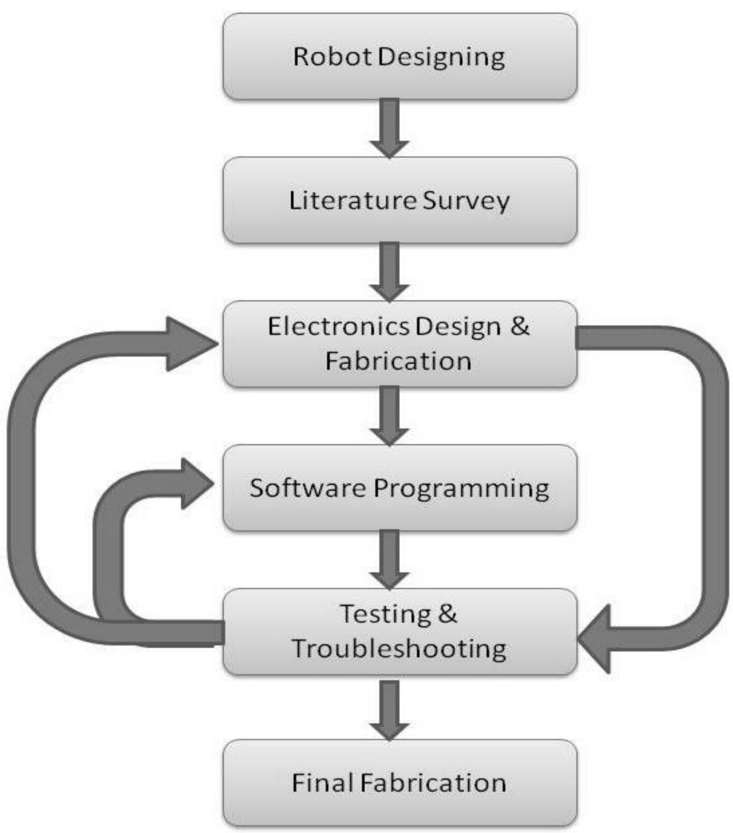


Fig. 5.1: Project flow chart

5.2 System Block Diagram

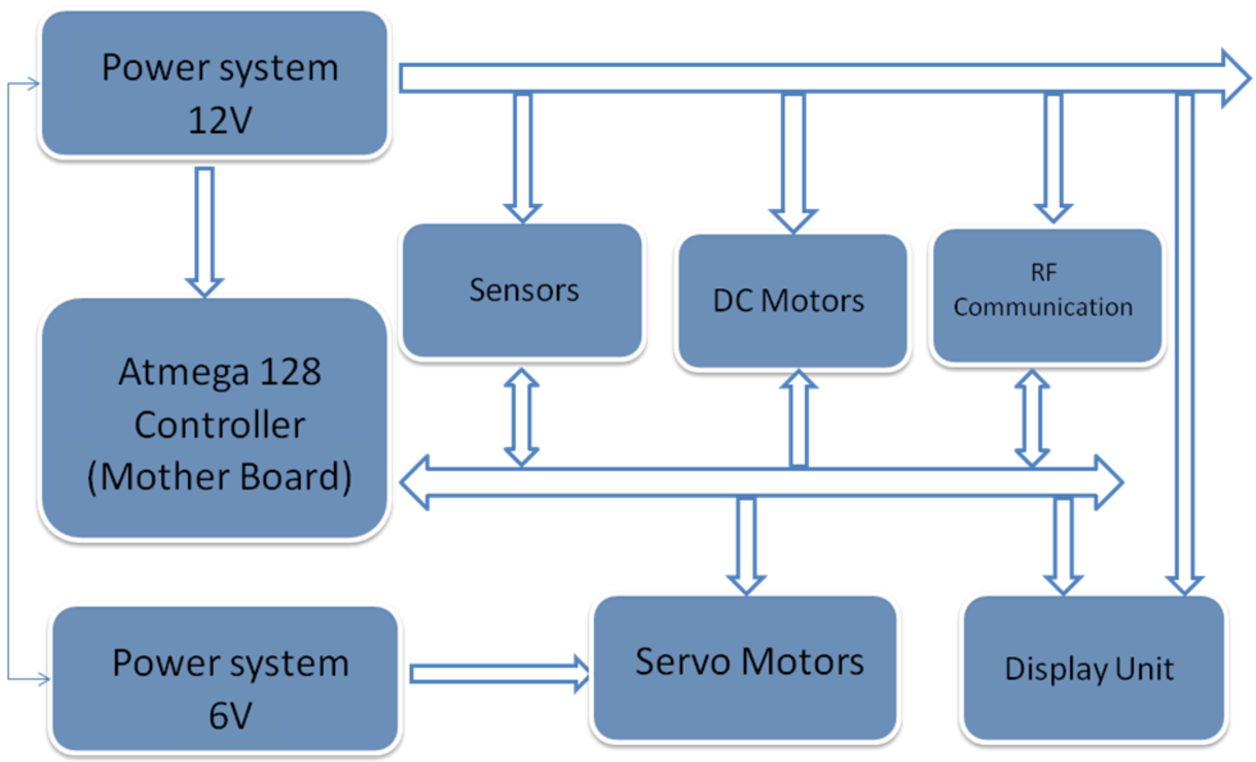
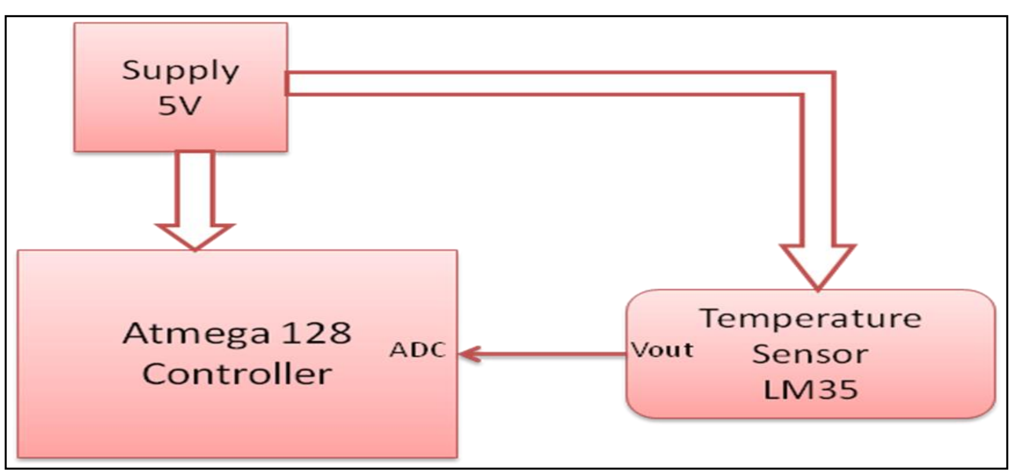
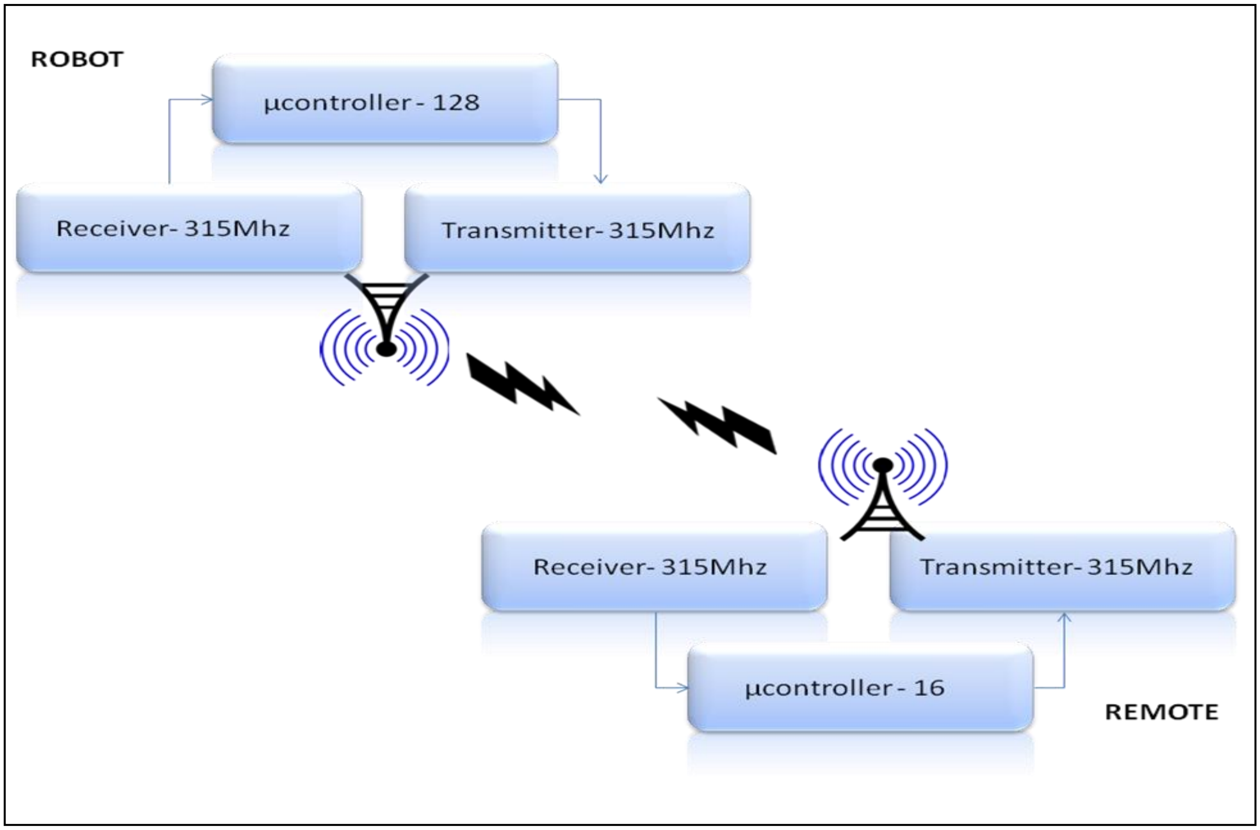
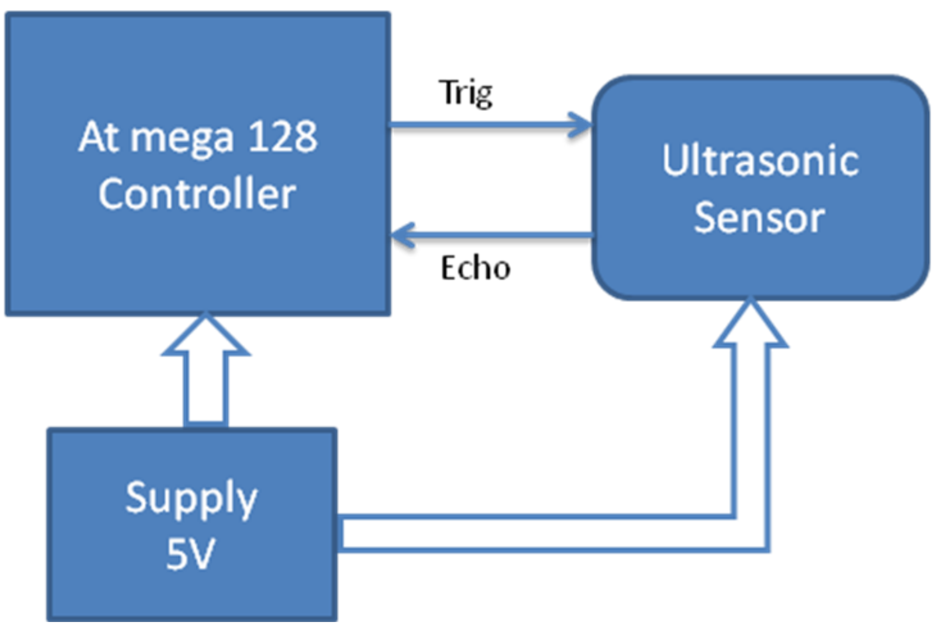
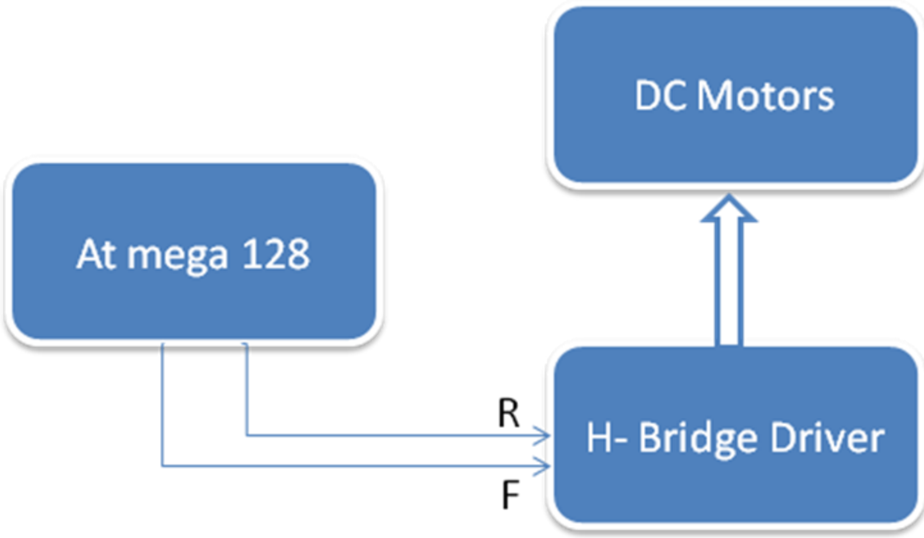


Fig. 5.2: System Block Diagram




ROBOT
µcontroller - 128
Receiver- 315Mhz
Transmitter- 315Mhz
Receiver- 315Mhz
Transmitter- 315Mhz
µcontroller - 16
REMOTE


At mega 128
Controller
Trig
Echo
Ultrasonic
Sensor
Supply
5V



Chapter 5

Applications

5.1 Space Missions

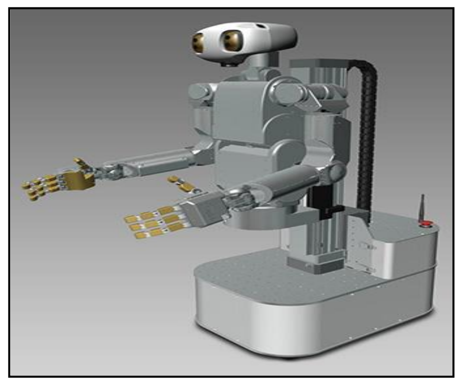
The humanoid prototype send for space mission are called as robonaut. *Refer figure 5.1,5.2.* A robonaut is a robot designed to assist humans in space exploration missions. As temperatures in space can have an extreme range, astronauts need to wear space suits that cost 12 million dollars apiece. They also need at least a few hours of preparation before they can respond to any emergencies like external repairs on an international space station caused by collisions with space matter. Because of these inherent difficulties that human astronauts face, robonauts that can be fielded in far less time and with far less cost are being considered.

Fig. 5.1: Robonaut1

Fig. 5.2: Robonaut2

Fig. 5.3: Mars rover

Human limitations and frailty in space have created the need for more versatile, robust and adaptive replacements in space-related tasks. In fact, robots have already served this need for more than 50 years starting with the planetary probe Mariner IV sent to bring back pictures of Mars. Likewise, the Pathfinder Mars rover was also sent to investigate the ground conditions in and atmospheric composition of Mars in 1997. *Refer figure 5.3.*



5.2 Industries

Industrial robots can easily automate picking a part up and placing it into a new location. Pick and place robots not only speed up the process, which increases production rates, but they are also more accurate and do not fatigue. Most of the movements that pick-and-place robots perform are back-breaking or hard to maneuver for humans**.**

The consistent output of a robotic system along with quality and repeatability are unmatched. Pick and place robots can be reprogrammable and tooling can be interchanged to provide for multiple applications.

Fig. 5.4: DLRs Justin

There are long term savings associated with a pick and place robotic work cell**.** An increase in output with a material handling robotic system has saved factories money. With the advancements in technology and affordability of robots, more pick and place robotic cells are being installed for automation applications.

Fig. 5.5: Torso robot

5.3 Household

An obvious domain for the use of humanoid robots is the household. Many domestic robots are used for basic household chores. Home transport robots are a main element in the domestic robotic system, because they join specialized processes, moving objects at home. While most domestic robots are simplistic, some are connected to WiFi home networks or smart environments and are autonomous to a high degree. Domestic Humanoids are perhaps also not too far in the future soon you'll be able to get your own humanoid butler/nanny/maid to perform those mundane household chores for you! Even walk the dog and pick up behind it. Some humanoid projects explicitly address this domain. One of them is the Motoman-SDA10 robot. *Refer figure 5.6.*

Fig. 5.6: Motoman-SDA10

5.4 Military and Law Enforcement

Robots used in military include bomb disposal robots, different transportation robots, reconnaissance drones. Often robots initially created for military purposes can be used in law enforcement, search and rescue and other related fields. If we can remove human soldiers, fireman and police officers (almost) completely from harm's way it would be a great achievement. *Refer figure 5.7.*

Fig. 5.7: Robocop

5.5 General Purpose

General-purpose humanoid robots can perform a variety of tasks autonomously. They are useful because they typically can navigate independently in known spaces, handle their own re-charging needs, and interface with electronics, networks, software and accessories.

They may recognize people or objects, talk, translate, provide companionship, monitor environmental quality, respond to alarms, pick up supplies and perform other useful tasks.

Because these robots mimic human beings and even resemble people in appearance, humanoid robots and androids are able to interact socially, intellectually and emotional with people. This can be useful to the young and old alike, in such roles as elderly care, babysitters, tutors, entertainers and companions.

And for the disabled and blind, an intelligent robot companion will be indispensable.

Chapter 6

User Guide

Read this chapter to learn about NARR's features how to use the controls, and more.

6.1 Know your Robot:

Fig. 6.1: Front View of the Robot

Fig. 6.2: Rear View of the Robot

Accessories

1. Remote.
2. Connecting Probes for remote.
3. Key-connector for the robot.
4. Charging Probes for robot.

6.2 Get Started:

A. Remote

1. Insert the connecting probes to the banana plug on the remote as per the colour code.
2. Connect the rear ends (crocodile clips) of the probes to the 12V DC battery (or power supply).

⚠ Warning: Do not short the battery terminals while connecting the rear ends of the connecting probes to the supply.

⛔ Note: Battery voltage should not exceed beyond 18 V.

3. Put the switch to ON mode to start the remote.

B. Robot

1. Connect the two banana plugs (black) using respective key-connector.
2. Connect the crocodile clips to the 6V battery as per the colour code.
3. Switch ON the mains button on the board.

⚠ Warning: Do not short the battery terminals while connecting the crocodile clips to the battery.

⛔ Note: The initial jerk of the limbs is the initialization for the same.

6.3 Modes:

Modes can be toggled easily by pressing the corresponding mode button any time in between the operation.

⛔ Note: Wait for short duration after the robot is fully ON.
⛔ Note: Do not press the buttons until prompted for.
⛔ Note: Pressing wrong button may hang the system.

A. Navigation Mode:

1. Press ‘N’ button on the remote.
2. Select the button assigned to the desired option displayed on the LCD.
3. Wait for the Robot to perform.
4. In ‘RF remote’, control keys are assign for different directions. Press the appropriate button once.

B. Hand Mode:
   1. Press ‘H’ button on the remote.
   2. Select the button assigned for respective hand.
   3. The limbs will assign themselves to the initialize position.
   4. Each joint can be controlled via 3 potentiometer knobs provided for the respective joints. Wait for the robot to perform before changing the values.
   5. Neck can be controlled by the knob provided for the same.

C. Sensor Mode:
   1. Press ‘S’ button on the remote.
   2. Select the button assigned for the desired sensor.
   3. Press the button again to get the updated value.

Chapter 7

Result

The Versatile Torso Pro-Bot was tested for is various modes of operation and the results for the same were as follows:-

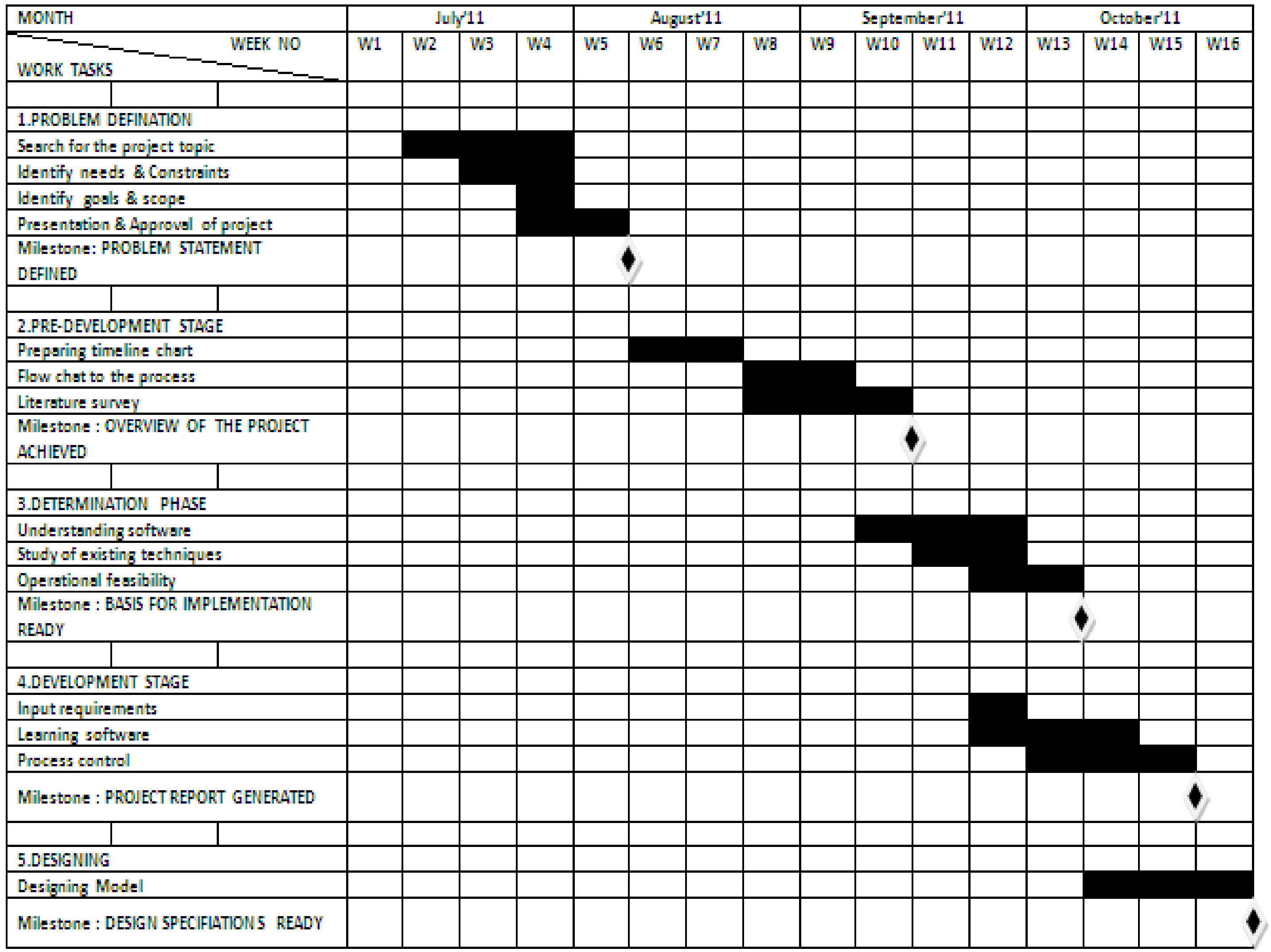
Modes	Task	Output
Navigation Mode 1. **RF Mode**	Uses navigation keys for its motion Key 2:Forward Key 4:Left Key 6:Right Key 8:Backward Key 1:Anti-clock Key 3:Clock Key 7:90° Anti-clock Key 9:90° Clock	
2. **Line following**	It follows a white line on a dark background. It also counts nodes and can take a turn at a respective node.	
3. **Pre-programmed**	It follows a particular routine and can perform task like pick-and-place, hand motion, head movement and so on.	
4. **Free mode**	Travels freely without colliding with obstacles. It uses ultrasonic sensor for the same.	
Hand Mode	Performs hand and head motion as per the positions of Potentiometer knobs. Right, left and both the hand movements can be controlled by this mode.	
Sensor Mode	The temperature of the surrounding and the alcohol concentration is sensed by the robot.	

Marquis Technology

Appendix A

Timeline Chart

TIMELINE CHART OF GROUP NO.17 FOR SEM VII



VERSATILE TORSO PROBOT

TIMELINE CHART OF GROUP NO.17 FOR SEM VIII

MONTH	January'12				February'12				Marchr'12			
WEEK NO / WORK TASKS	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12
6. ASSEMBLING												
Circuit Assembly												
Programming Controllers												
Assembly of Model												
Milestone: PROTOTYPE READY												
7. TESTING & IMPLEMENTATION												
Testing and Reassembling												
Troubleshooting												
Final Touch												
Milestone : SYSTEM TESTED & IMPLEMENTED												
8. DOCUMENTATION PHASE												
Showing results to Guide												
Final presentation												
Final Report												
Milestone : PROJECT & DOCUMENATION COMPLETE												

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